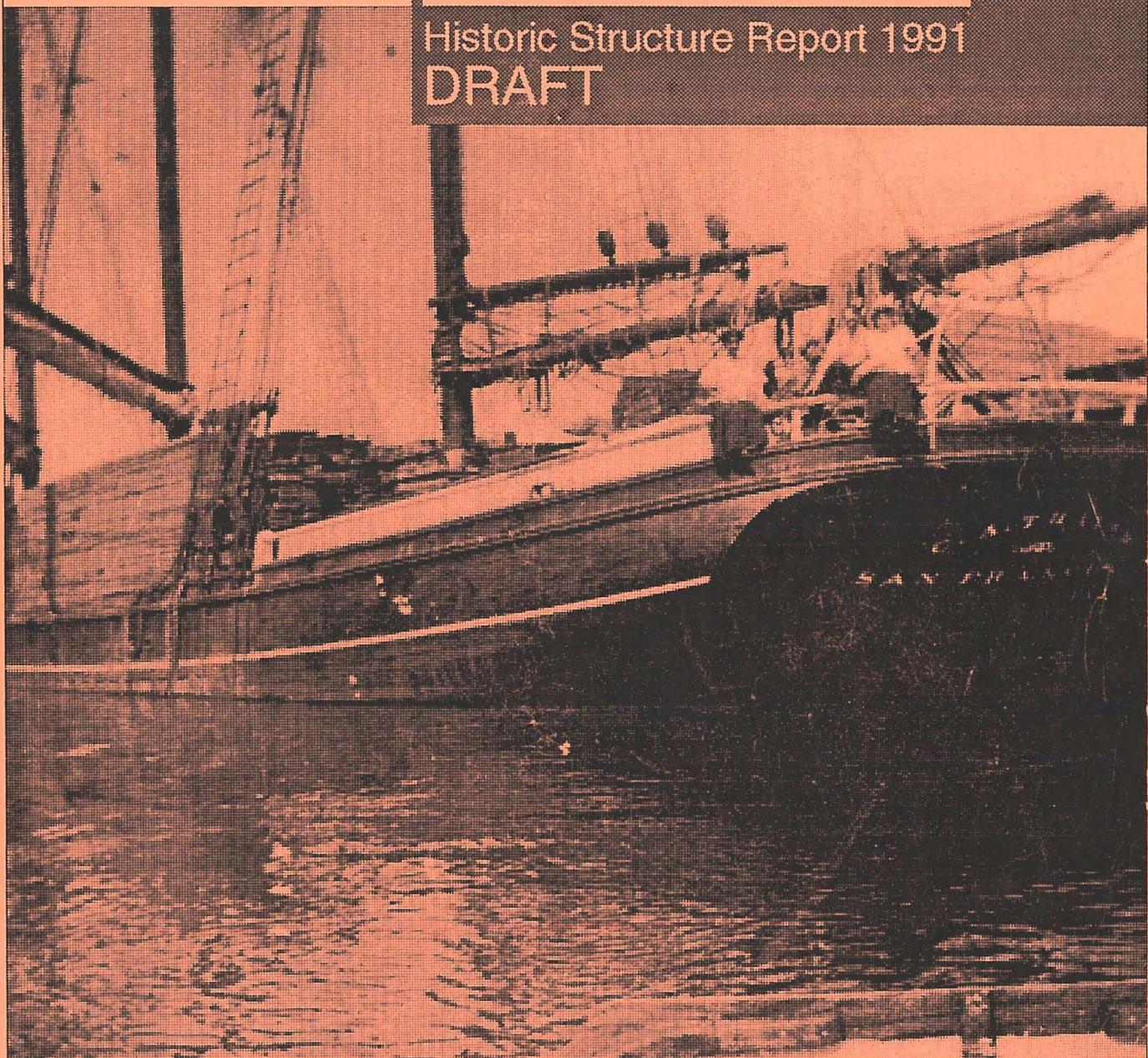


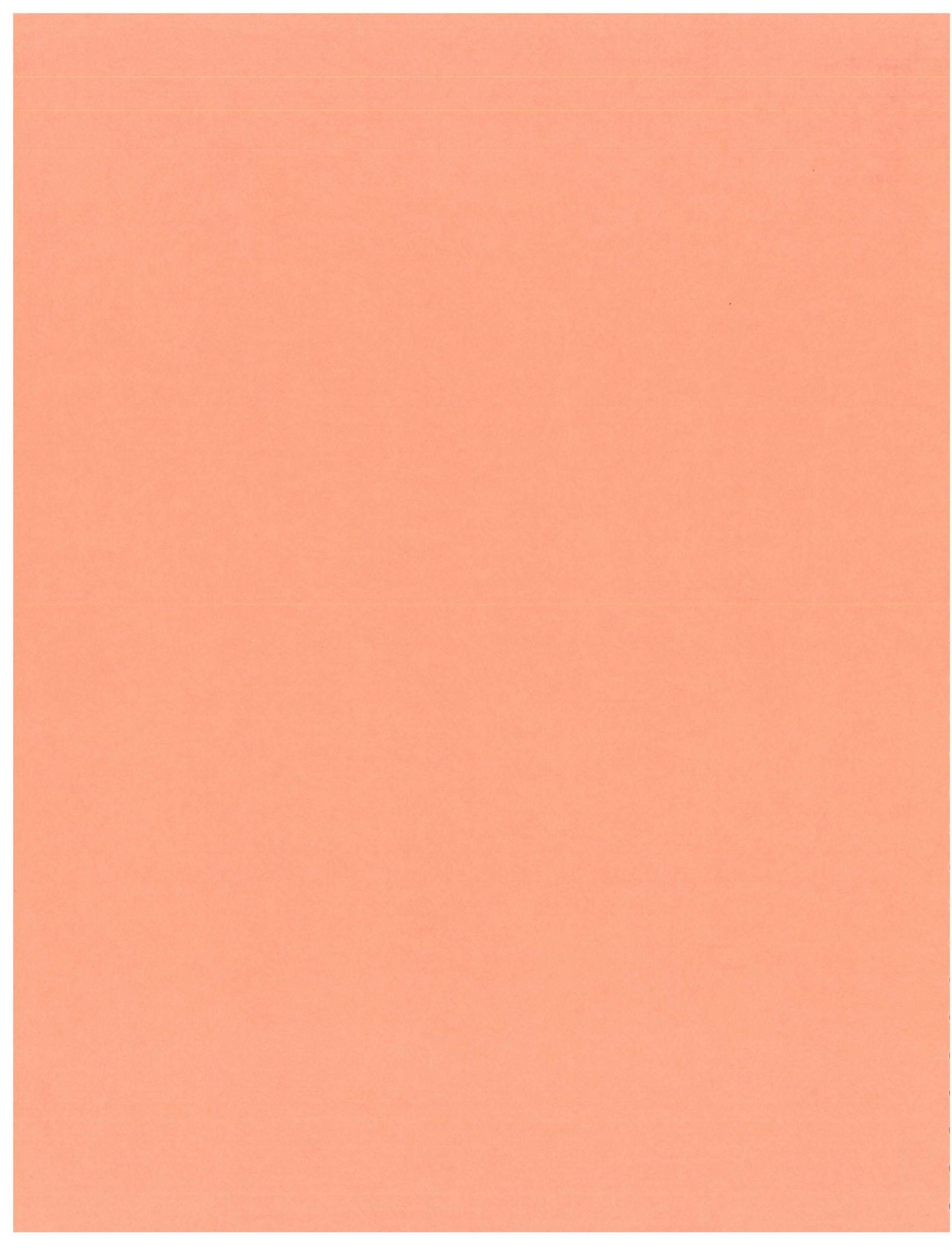
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SCHOONER *C.A. Thayer*

Historic Structure Report 1991
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San Francisco Maritime National Historical Park



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C.A. Thayer

Historic Structure Report 1991
DRAFT

Prepared for
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■ Introduction

C.A. Thayer is one of two surviving Pacific lumber schooners, a type of vessel instrumental in the development of the West Coast during the late 1800s and early 1900s. She has served a long and successful career, from her launching in 1895 to her last trip in the codfishing trade in 1950. A popular exhibit at the Hyde Street Pier for nearly thirty years, *C.A. Thayer* has become an integral part of the Maritime Park and the San Francisco waterfront.

Today she faces a dilemma that, ironically, is largely due to her longevity—she has outlived the practical life span of her construction material, Douglas fir. Ravaged by dry rot, she has lost much of her structural integrity and has become increasingly difficult to maintain.

If *C.A. Thayer* is to survive into the next century, major

action must be taken in the near future. Difficult decisions will have to be made, as none of the options for the vessel's preservation are without drawbacks.

The Historic Structure report is intended to serve as a resource for those who will decide *C.A. Thayer*'s future. The report includes documentation of the vessel's existing condition in a structural survey and in measured scale drawings. The physical changes the vessel has undergone during her lifetime are recorded in a "physical history," and the historical significance of the various elements of the vessel is given in an "assessment of fabric and features." The heart of the report is a proposal for treatment, including cost estimates and a recommended schedule for implementation.

This report should be viewed as only a starting point for the considerable planning and study that will be necessary to ensure *C.A. Thayer*'s long-term preservation.

■ Management Synopsis

The 1895 three-masted lumber schooner *C.A. Thayer* is a National Historic Landmark and one of the fleet of seven historic ships of the San Francisco Maritime National Historical Park. She is currently open to the public at the Hyde Street Pier in San Francisco, where she has been on exhibit since 1963. Although *C.A. Thayer* continues to function successfully as an interpretive exhibit, her long-term preservation has been rendered problematic by the advance of rot in her hull and deck structure. In her present deteriorated state, she cannot be effectively maintained in an exposed environment.

The following treatment options were considered:

- 1. Maintaining the present course of action, no major intervention

Without major intervention, the vessel will continue to deteriorate at an increasing rate. Expected remaining life-span under this scenario is little more than ten years, after which the vessel would become a constructive loss.

- 2. Permanent dry-berthing for exhibit ashore

Dry-berthing would remove *C.A. Thayer* from her historic context and would not guarantee her long-term preservation, as there is no history of

success in preserving large wooden vessels ashore.

- 3. Restoration for continued exhibit afloat

Restoration would return *C.A. Thayer* to a sound, maintainable condition, thus allowing her to remain afloat. This option is seen as the best means of preserving the vessel's historic integrity over the long-term.

The recommended treatment is full structural restoration through in-kind replacement of deteriorated fabric. Where possible, historic fabric would be preserved using modern preservation technology.

Considerable time will be required for preparation, primarily for air-drying the lumber needed for restoration. Steps to stabilize the vessel are recommended to prevent further deterioration during this interim period.

A two-phase program is proposed as follows:

Phase I: FY 1990-91

- Initial Planning
- Structural Stabilization

Estimated Cost: \$395,000-\$640,000

Phase II: FY 1992-2000

- Restoration Planning and Materials Preparation
- Drydocking for Restoration (FY 1999-2000)

Estimated Cost: \$5,022,000-\$6,318,000

Total Cost of

Proposed Treatment: \$5,264,000-\$6,655,000

SCHOONER *C.A. Thayer*

Historic Structure Report 1991
Administrative Data

■ Administrative Data

□ Project Identification

The schooner *C.A. Thayer* is docked at Hyde Street Pier, in San Francisco. Hyde Street Pier is leased from the Port of San Francisco by the National Park Service, and administered by San Francisco Maritime National Historical Park.

The *C.A. Thayer* is identified as a primary resource of the park in the San Francisco Maritime National Historical Park Act of 1989, Public Law 100-348, June 27, 1988. The *C.A. Thayer* is No. 12951 on the National Park Service List of Classified Structures (LCS). *C.A. Thayer* has been declared a National Historic Landmark. LCS data:

National Register Status: . . . Entered, Documented
Management Category . . . A, Must Be Preserved
Documentation Documented
Period Historic
Significance National
Approved Ultimate Treatment Preservation
National Register Reference Number . . . 66000229
For more information, see Appendix 4, which contains a more detailed LCS report.

□ Proposed Use

The *C.A. Thayer* is listed on the LCS in the Management Category A: Must be Preserved. Currently, the vessel is open to the public seven days a week, is the primary site for the SAFR's youth-oriented Environmental Living Program (run in cooperation with Orange County Marine Institute, the program has reached over 80,000 children throughout the West) and hosts community events throughout the year. The proposed treatment of this historic ship is preservation/interpretation. Successful implementation of this treatment plan—in a series of orderly phases—will ensure long-term preservation and provide an unparalleled interpretive resource.

□ Use Justification

Preservation and interpretation of the *C.A. Thayer* is in keeping with NPS policies and guidelines, and is consistent with the goals of the San Francisco Maritime National Historical Park.

□ Work Product Preservation

All objects, documents, records, photographs, negatives and files collected or produced as a result of this study must become part of the park's museum collection to be preserved, managed, and stored in the Division of Collections Management, San Francisco Maritime National Historical Park, at the conclusion of this study.



SCHOONER *C.A. Thayer*

Historic Structure Report 1991
Physical History and Analysis

■ Chronology of Physical History

The three-mast schooner *C.A. Thayer* is typical of a large class of wooden sailing vessels built for the lumber trade along the Northwest coast of the United States in the latter part of the 19th century. She is one of only two survivors of the more than 500 wooden sailing vessels of over 100 tons that were built in the region from 1860 to 1905. *C.A. Thayer*'s longevity has carried her through five different occupations since her launch in 1895. Each has occasioned modifications, though she was never fitted with mechanical propulsion, and came to her current museum usage having been the last working sailing vessel on the Pacific Coast (Olmsted 1972). Though much of *C.A. Thayer*'s fabric has been replaced over the near-century of her existence (and more will have to be replaced if she is to continue to survive), she is seen today in very nearly the configuration with which she was launched. Exceptions are noted in the following chronology of her physical history.

The major periods of *C.A. Thayer*'s history are as follows:

1895—1912 Service as a lumber carrier for her owner, the E.K. Wood Company, carrying cargo between their lumber mill at Hoquiam, Washington, and various ports along the West Coast and the Pacific.

1912—1924 Service to the Alaskan salmon salteries of owner "Whitehead" Pete Nelson at Bristol Bay in Western Alaska, carrying supplies and workers north in the spring, and returning with barrels of salt salmon at the end of the season. On several occasions during this period, she engaged in the transport of lumber across the Pacific during the winter months.

1924—1931 The first of two periods of service in the Bering Sea codfishing industry, based in Poulsbo, Washington, under the ownership of the Pacific Coast Codfishing Company. This trade involved six-month cruises in the Alaskan Arctic with a crew of thirty or more fishermen, tending dories and salting the catch aboard until a full hold or the advancing winter sent her home.

1932—1942 Period of layup at Lake Union in Seattle, Washington.

1942—1945 Wartime service as a barge for the U.S. Army in British Columbia and Southeastern Alaska.

1946—1950 Second period of service in the codfishing industry.

1950—1957 Period of layup, including service for a time as a beached roadside attraction, billed as a "pirate ship."

1957—1991 Period as museum vessel, under State of California and subsequently under the National Park Service.

□ Lumber Carrier: 1895–1912

1895
Construction

C.A. Thayer was built at the Fairhaven Shipyard of Hans Bendixsen on Humboldt Bay, California, and launched on 9 July, 1895. "The vessel was built for the E.K. Wood Lumber Company. She will run between Gray's Harbor and San Francisco in the lumber trade. The length is 156 feet, breadth 36, and the depth 11.8. The gross tonnage is 452.29." She was equipped with a steam "donkey hoist" built by the Humboldt Iron Works (*Humboldt Daily Standard* 1895). She had a total of nineteen owners when built, including a 1/4 share held by her builder. A controlling interest was held by the E.K. Wood Lumber Company, whose Secretary, the C.A. Thayer for whom the vessel was named, held no shares in his own right (Olmsted 1972).

1895, 18 June
Maiden Voyage

"The schooner *C.A. Thayer*...sailed yesterday [17 June] in ballast in command of Captain Lillquist for Gray's Harbor to load lumber for the Fiji Islands. This is the first vessel built here that has left on her maiden voyage without a cargo of Humboldt redwood" (*Humboldt Times* 1895). Her cargo consisted of 560,000 board feet of lumber (*Humboldt Standard* 1895). Her maximum capacity is said to have been 575,000 board feet, about half of which was carried as deckload

(Olmsted 1972).

On her return to the West Coast, *C.A. Thayer* commenced her intended routine of transporting lumber from Gray's Harbor to San Francisco, San Diego, San Pedro, and other coastal communities, with occasional voyages across the Pacific to Honolulu.

Ca. 1903
Donkey Engine Removed

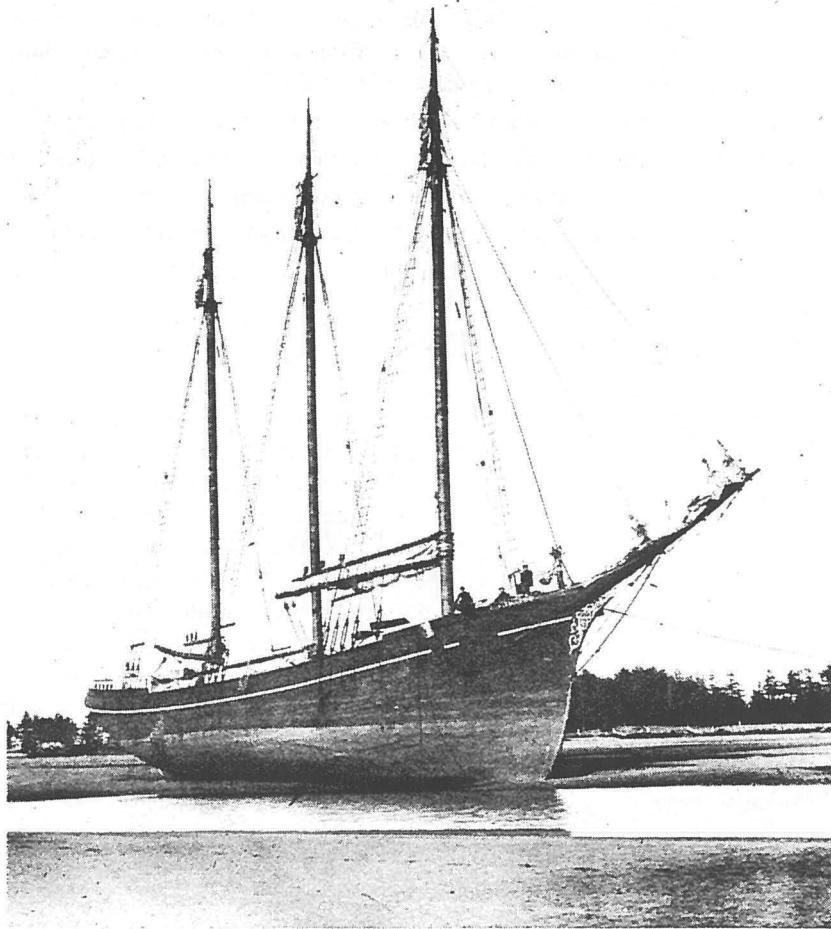
A deckhand aboard *C.A. Thayer* during a voyage in 1903 to Honolulu and return, a voyage of four months, recalls that: the deck load was 12' high, with a ramp built from the forecastle to the top of the forward deckhouse; she carried no donkey engine during that time—lumber was “loaded by hand;” she “sailed herself” light (with little or no cargo) on the return trip, making 10 or 11 knots; entering Gray's Harbor on her return she struck the bar several times, but was not damaged (Bratrud 1963).

1903
Stranding

Under the command of Captain Ole Monsen, *C.A. Thayer* went ashore on the North Spit of Gray's Harbor on 8 November 1903. She was refloated by 2 December however, with damage limited to the loss of her rudder, rudderpost, and both anchors. (*Marine Exchange* 1903) Her crew of eight men were taken

Fig. 1. *C.A. Thayer* stranded at Gray's Harbor, Oregon, 12 November 1903.

Photo: SFMNHP E3.8497n



off safely with the assistance of the U.S. Lifesaving Service (U.S. Lifesaving Service 1904).

Photographs taken at the time of her stranding (SFMNHP No. E3.8495) clearly show her shape and her rig during this time of service in the lumber industry. She is seen as a three-mast “bald headed” schooner, with masts of equal height. Above the upper mast bands, to which triatic stays are fixed, “pole” topmasts taper to a round truck onto which small topsails are bent with hoops (Lee 1957). Her masts are not cut square at the cap, as would be the case with a schooner designed to carry topmasts. She is rigged with deadeyes and lanyards on the standing rigging. She has a spike bowsprit in these photos, not the bowsprit-and-jibboom arrangement described by Capt. Ole Lee as carried in 1918 (*ibid.*) and as appears in later photographs (SFMNHP No. F16,35,380n).

Also visible at this time are the raised pinrails on the shrouds, one of the modifications demanded by the practice of carrying great deckloads of lumber. For the same reason, permanent obstructions on deck, such as foot blocks, bitts, deck pumps, etc., were avoided and there were no “ladder railings—rope, pipe, wire or otherwise; there are no places for drunks aboard” (Klebengat 1975).

1904
Sail Damage

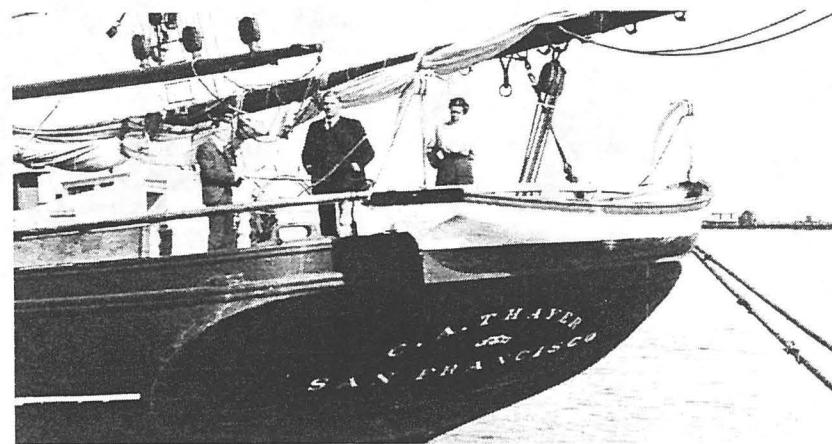
In 1904, *C.A. Thayer* is reported to have lost her jib and main sail in a gale (*Marine Exchange* 1904). Although it is recorded in the archives of the San Francisco Marine Exchange, this cannot have been an unusual occurrence. Capt. Ole Lee describes *C.A. Thayer*’s trip under his command fourteen years later: “One day off the Mexican coast a squall took the forestaysail right out of the boltropes. Our sails were five years old. My job was sewing all the time, every day. That’s all I done” (Lee 1957). A now-familiar photograph taken by Karl Kortum on the delivery trip from Lake Union to San Francisco in 1957 (see fig. 9), more than forty years later, shows *C.A. Thayer* in a gale, her mainsail down and under repair by the sailmaker (SFMNHP Photo No. K9.38806n).

1912
Towed into Port, Leaking Badly

On 14 January 1912, *C.A. Thayer* radioed for assistance (the first mention of her being equipped with radio) while some twenty miles off the Humboldt Bar. She was “leaking badly and in momentary danger of sinking” despite continual

Fig. 2. Captain and Mrs. G.T. Peterson aboard *C.A. Thayer* at San Pedro Harbor, December 1905.

Photo: SFMNHP D9.7883n

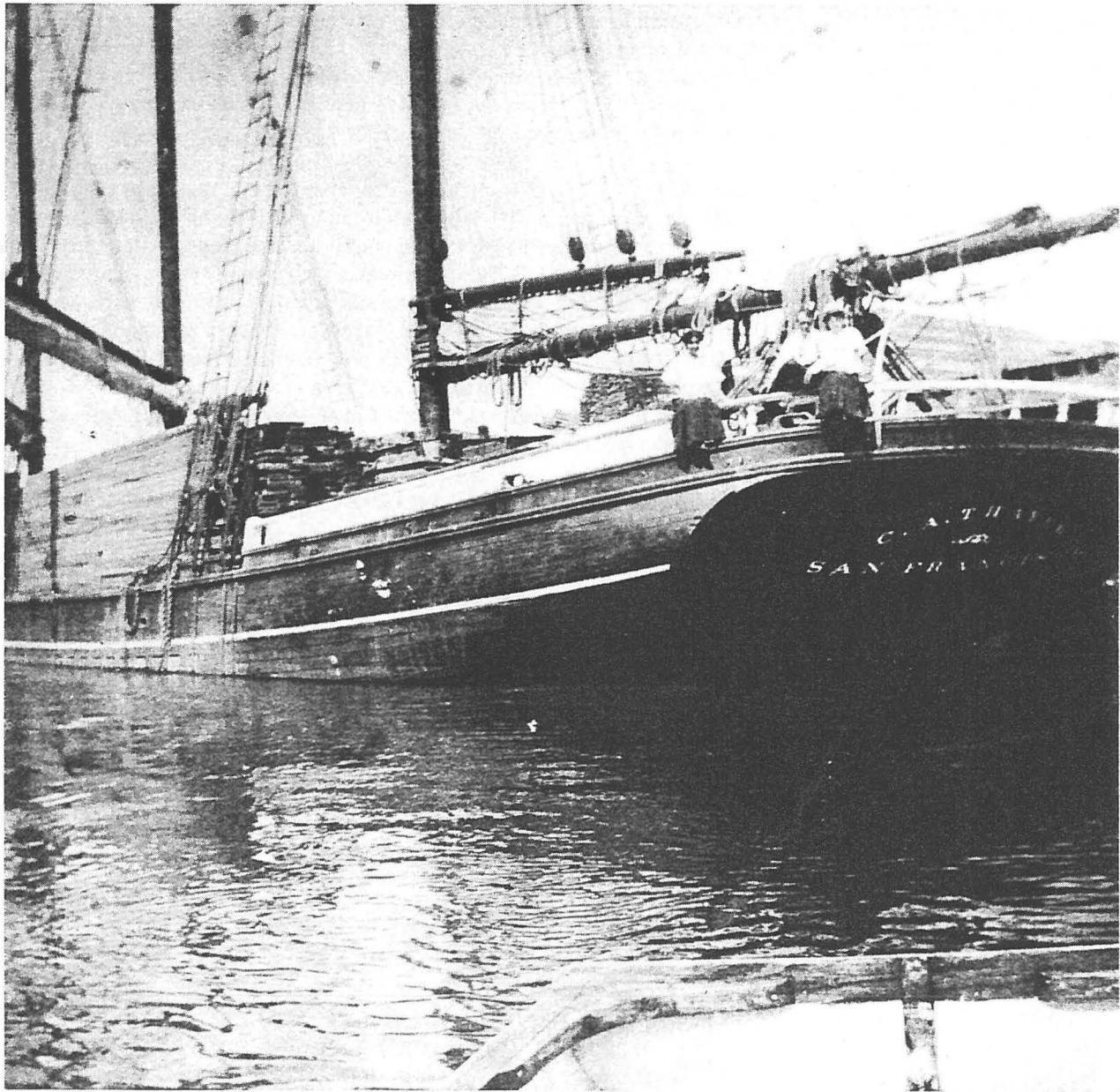


pumping (*Marine Exchange* 1912). She had been at sea for eleven days when she was taken in tow by the steam tug *J.B. Stetson* and towed into port, the Captain, his wife, and seven crew unharmed. "She had simply opened up; fresh water for the donkey boiler (reappeared after the absence in 1903 as reported by Bratrud) had run out; the hand pumps had clogged."

The \$9,000 bill for this rescue, plus the prospective expense required to make her seaworthy again, apparently came to more than was profitable to spend on a lumber carrier in 1912, and the vessel was laid up (Olmsted 1972).

Fig. 3. Loading lumber at Hoquiam, Washington, 1912. *C.A. Thayer* carried as much as half of her cargo on deck. Note the minimal freeboard below the line of the scuppers at the main deck level.

Photo: SFMNH F1.6376n



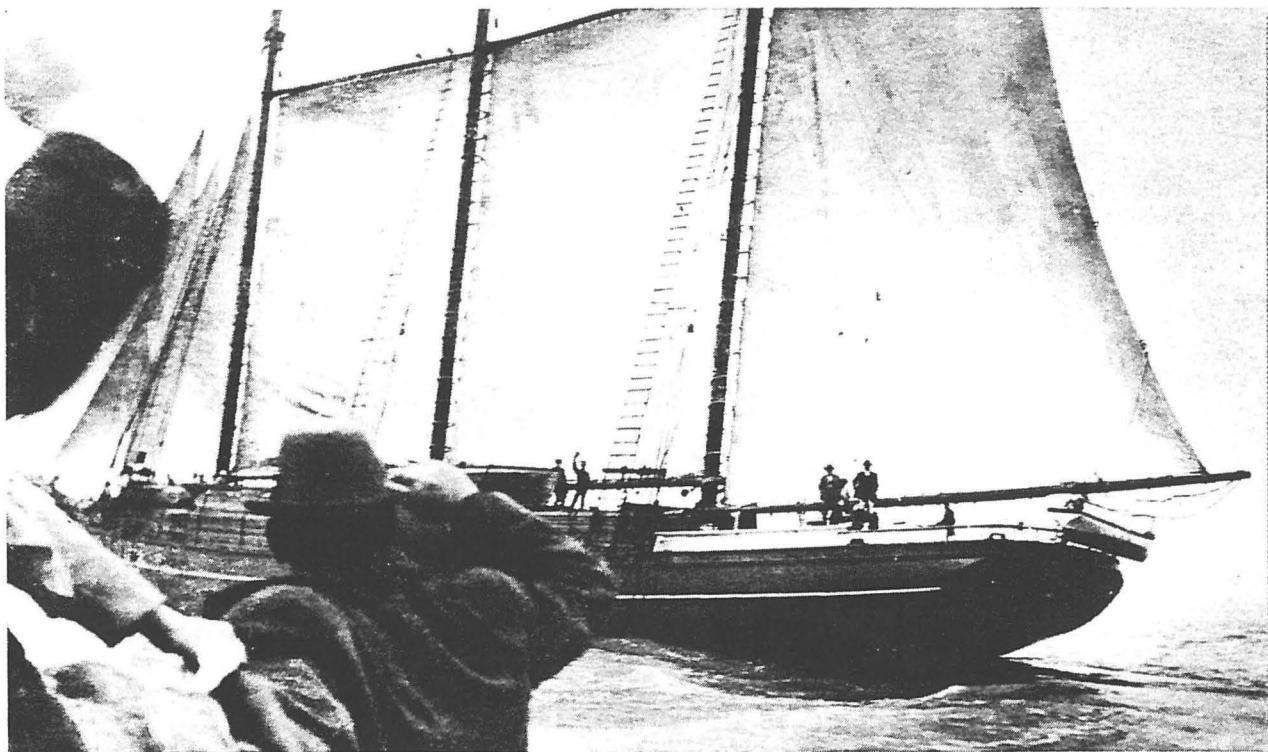


Fig. 4. *C.A. Thayer* bound for Bristol Bay, Alaska, with a full deckload of lumber, 1912.
Photo: SFMNHP J7.5.134n

□ Alaskan Salmon Industry Service: 1912–1924

1912

Change of Ownership

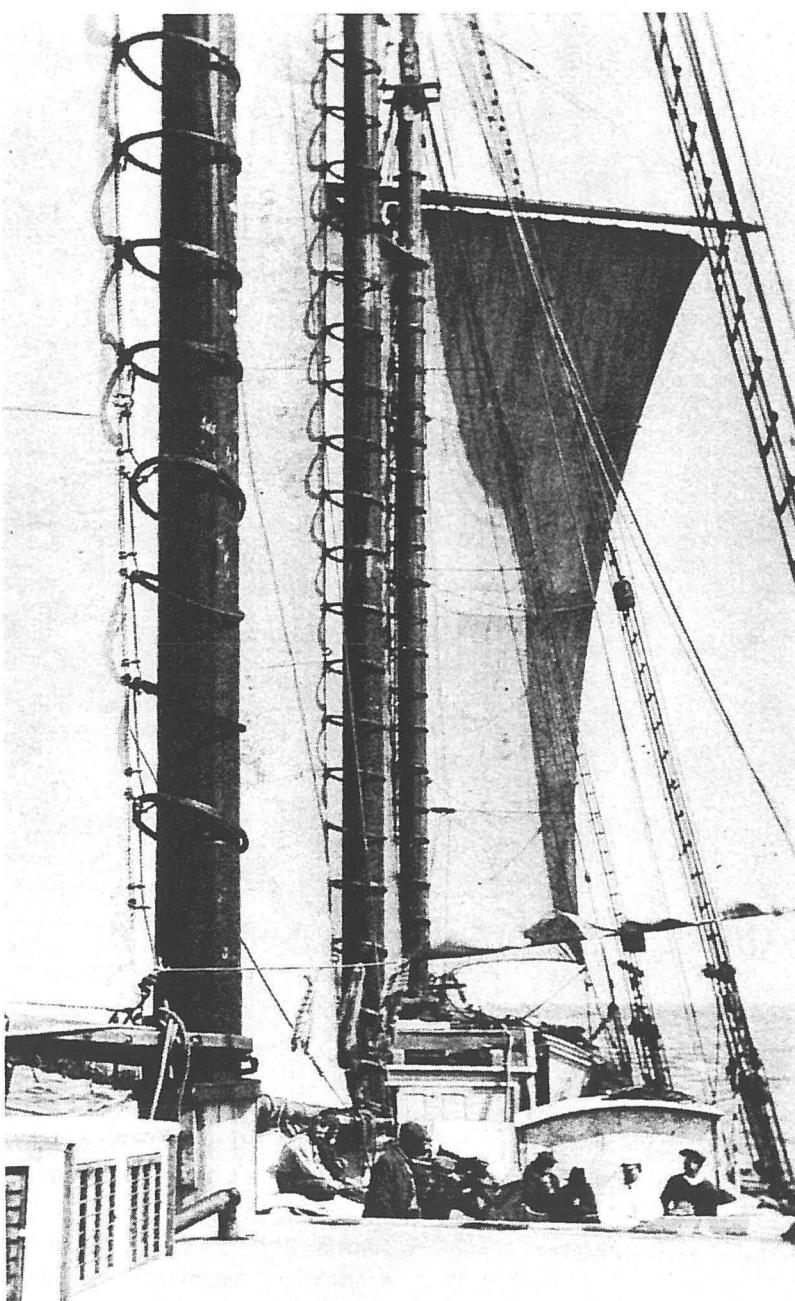
In 1912, *C.A. Thayer* was purchased by “Whitehead” Pete Nelson for about \$10,000 to serve as a market and supply boat for his small salmon salteries in Bristol Bay, Western Alaska. Salmon were caught with shore-based open boats and processed in Nelson’s salteries at Igushik and Squaw Creek. *C.A. Thayer*’s job was to transport supplies, fishermen, and saltery hands north in the spring, and to return them with the catch at the end of the season (*ibid.*).

Few modifications seem to have been made to the vessel for this trade; certainly none which made her unsuitable for lumber carriage, for during the years of World War I, when freight rates were high, *C.A. Thayer* was sent with lumber to Australia in the off-season. The aging vessel suffered some damage to rig and sails during the trip to Australia in 1918–19, and is reported to have leaked badly on the homeward-bound passage (Lee 1957). A photograph from this period shows her with the a West Coast-style square foresail set on its yard on the foremast. This was a two-part sail which brailed into the mast, rather than up to the yard, so that the weather half, which would not be blanketed by the large gaff foresail, could be set alone (SFMNHP Photo No. J9.23.813n).

C.A. Thayer persevered in the salmon trade until 1924, when freight rates dropped in the postwar slump and the salmon industry came to be dominated by the canneries with their need for larger vessels (among the vessels brought

Fig. 5. View of deck, looking forward, during a voyage to Alaska, ca. 1914. Note the West Coast-style square foresail. This sail was set on hoops on the fore yard. Brails, lines which draw the sail into the mast for furling, are visible. The gypsy head powered by the donkey engine can be seen atop the deckhouse, with a line draped over it.

Photo: SFMNHP J9.23813n



into the salmon cannery and kept working well into the 20th century was the Scottish-built full rigger *Balclutha*, renamed *Star of Alaska*. *Balclutha* is today the flagship of the NPS fleet of historic ships). The *C.A. Thayer* was sold in 1924 into a yet more demanding trade.

□ Bering Sea Codfishery Service: 1924–1931

1924
Change of Ownership

C.A. Thayer was bought by J.E. Shields of the Pacific Coast Codfishing Company of Poulsbo, Washington, in 1924. In this service she made yearly trips

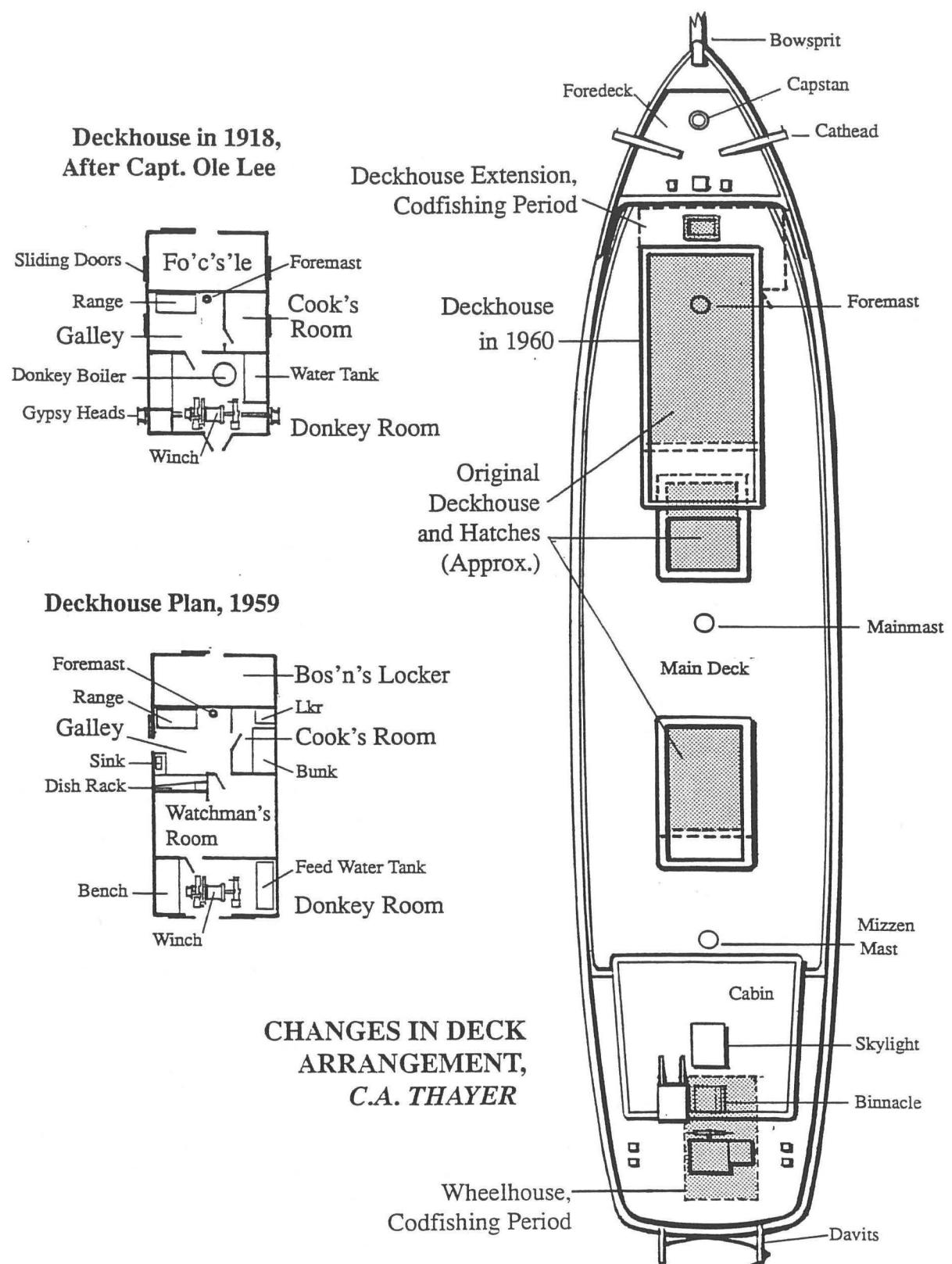


Fig. 6. Changes in deck arrangement.

Graphic: D. Canright, Tri-Coastal Marine

1924-1931
Modifications

of six months at a time to the fishing grounds of the Bering Sea, carrying fishermen and dories, and salt to preserve the season's catch.

Codfishing brought a number of changes in configuration to *C.A. Thayer*. Although the dates of these changes cannot be determined with certainty, they may be listed as follows:

- Additional bunks were built for the fishermen, amidships in the berthing area, or "fishermen's forecastle," at the forward end of the hold (Nelson 1983).
- The deckhouse was extended forward to the break of the forecastle head, and widened on the starboard side to provide a companionway into the galley, the crew dining area (forward, where the bosun's locker is now located), and the fishermen's forecastle (SFMNHP Photo No. P78-086a).
- 100-gallon drums were mounted on the main deck to provide a supply of fresh water for extended periods at sea (Nelson 1983).
- The size of the fore hatch opening was reduced.
- The donkey engine was moved forward, with the gypsy head mounted on the deckhouse roof, forward of the mast (ibid.).
- In addition to the traditional stern davits of her original equipment, six pairs of steel davits were fitted along the caprail, port and starboard, to handle the fishermen's dories. These dories, originally the traditional two-man sail and oar powered type that nested on the deck, were replaced ca. 1927 by larger one-man boats powered by small outboard motors and protected by canvas dodgers. Although they could not be nested, fewer of them were needed because of the greater efficiency of their motorized operation. Large gasoline tanks were mounted in the hold to fuel the dories (Lucas 1957).

□ Layup and Service as Barge: 1931-1945

1931-1941
Layup

Although the season of 1931 had seen a record catch, the Great Depression caught up with *C.A. Thayer* in 1932, when a sharp drop in the price of codfish initiated a period of layup on Lake Union, Washington. The layup was to last ten years (Olmsted 1972).

1941
Change of Ownership and
Conversion to Barge

As the United States geared up to fight the Second World War, cargo vessels of any kind suddenly came to be in great demand. *C.A. Thayer* was purchased in 1941 by the U.S. Army. Her masts were removed (they could not have been fit for use after ten idle years) and after "quite a bit of money" had been spent on making her bottom sound, she was put to work as a barge in British Columbian and southern Alaskan waters. (Olmsted 1972). A note on the receipt to the U.S. Army for hauling out the "Barge *C.A. Thayer*" indicates a maximum hog of 6 inches (Winslow Marine Railway and Shipbuilding Co. 1943).

Other modifications appear to have been made by the Army; although no confirming historical documentation has been found, existing physical evidence in *C.A. Thayer*'s structure indicates that both the fore and main hatches were lengthened at one time. This would not have been desirable for any of *C.A. Thayer*'s oceangoing trades, but would be in keeping with the Army's use of the vessel as a cargo barge. The main hatch, originally measuring 15 feet fore and aft, was lengthened by cutting through the deck beam at the aft end of the hatch and installing longer carlings, thus extending the hatch aft

by 4 feet (it remains in this configuration today). The fore hatch was similarly lengthened by extending it forward by 8-1/2 feet (Tri-Coastal Marine 1987).

□ Return to Codfishing Service: 1946–1950

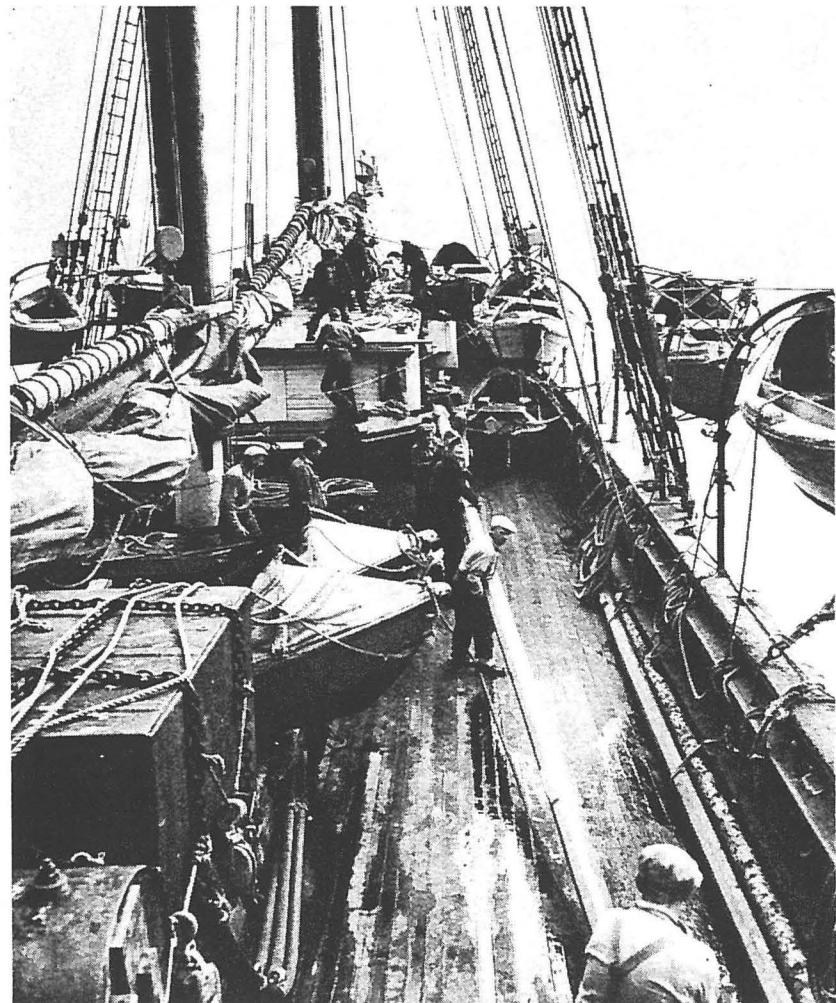
1946

Change of Ownership and
Conversion

At the War's end, J.E. Shields bought *C.A. Thayer* back from the Army. The vessel was now of fairly sound bottom and Shields proceeded to re-rig her using portions of his unseaworthy four-mast schooner *Sophie Christenson*, also laid up in Lake Union. With three of *Sophie*'s masts, her standing rigging, and headgear, *C.A. Thayer* was ready for sea, though not restored to her previous state. Her shrouds did not quite reach her chainplates and had to be extended with doubled steel straps bolted into place. Her deadeyes and lanyards were replaced with open turnbuckles. Her tapering pole topmasts were gone, as *Sophie* had been rigged with fiddled topmasts, and her gaff-headed mizzen sail was replaced with a smaller, easier to handle jib-headed or leg-of-mutton sail (Olmsted 1972). Finally, a wheelhouse was built over her steering station (SFMNHP Photo No. F9.17856n). Later, her spike bowsprit was replaced by a

Fig. 7. *C.A. Thayer* during her last codfishing period, ca. 1946-50. Changes made since 1914 are evident: the deadeyes and lanyards have been replaced by turnbuckles; the gypsy head is absent from the aft end of the deckhouse top; davits have been installed for the dories (spare davits are seen lashed to the fuel tank at lower left); a continuous pinrail has been added along the length of the bulwarks.

Photo: SFMNHP F9.8493n



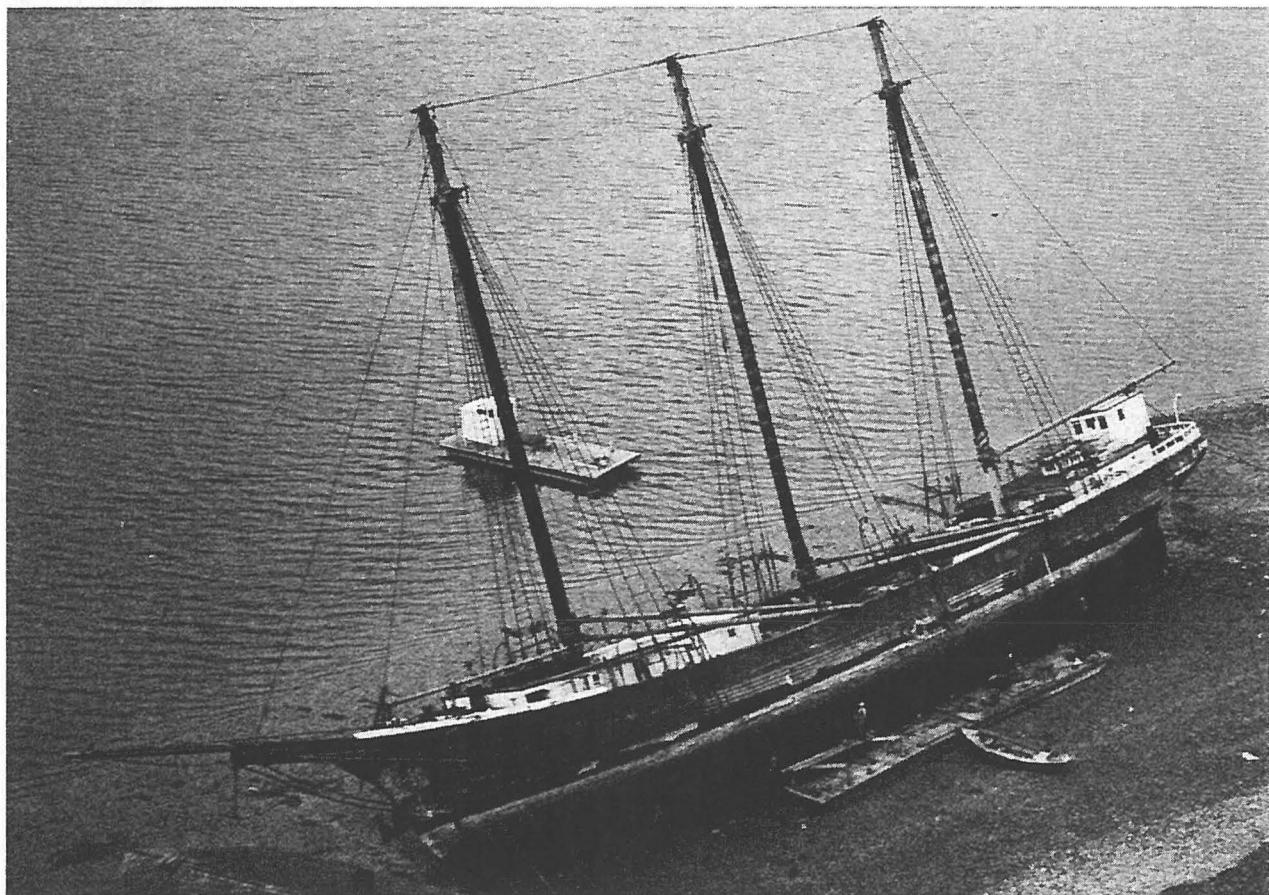


Fig. 8. *C.A. Thayer* careened for repairs and bottom painting, at the end of her working career, 1951. Note the bowsprit and jibboom that have replaced the original spike bowsprit seen in Fig. 1. The masts have been salvaged from the four-mast *Sophie Christenson* and are without the characteristic pole topmasts. The wheelhouse and forward extension of the deckhouse, both modifications from the later codfishing period, are clearly evident.

Photo: SFMNHP F16.35,380n

bowsprit-and-jibboom arrangement (SFMNHP Photo No. F16.35380). In this makeshift condition, *C.A. Thayer* sailed five more seasons to the Bering Sea, becoming the last sail-powered commercial vessel in operation on the West Coast (Lucas 1954).

□ Beached Attraction: 1954–1957

After her last season of codfishing in 1950, *C.A. Thayer* was again laid up in Lake Union. In 1954, J.E. Shields sold her to Charles McNeil, who for a time exhibited her as a “pirate ship,” beached on a gravel bar at the head of the Hood Canal (Olmsted 1972).

□ Museum Vessel: 1957–1991

1957
Change of Ownership

The State of California purchased *C.A. Thayer* from Charles McNeil for \$25,000. She was acquired to become part of the California State Maritime

1957
Restoration

Historical Park (ibid.).

The first stage of *C.A. Thayer*'s restoration as a museum vessel was undertaken in May of 1957 at the Lake Union Drydocks. *C.A. Thayer* had undergone extensive hull repairs in 1941, and had been beached and careened at least as lately as 1950; but in 1957, it was obvious that she would need some restoration simply to bring her to her new home in San Francisco. Her hand-me-down rig had been old when installed twelve years before, and was now extensively rotten. It was decided to restore her in Lake Union to the extent that she could actually be sailed back to San Francisco. By the time she was ready to put to sea, this work had grown to include the following:

- Hull: forecastle sheer strake replaced, port side; two bottom planks replaced, starboard side; keel repaired from the forefoot to 30 feet aft, 3,600 feet of seams recaulked; topsides sandwashed and painted; bottom painted.
- Stern: installed one new frame and three sister frames at port and starboard quarters; installed six new frames and four sister frames in the transom; removed one deck and installed a sister beam, cut off deteriorated ends of other deck beams and installed steel angle supports; replaced "horseshoe" timbers, covering board, bull rail, and caprail around stern; replaced 119 feet of transom planking, 136 feet starboard quarter planking, and 66 feet port quarter planking; installed new bitts at starboard quarter.
- Forecastle Head: renewed bull rails and portions of rotten covering boards; renewed catheads and pawl bitts; renewed deck beam at the break of the forecastle and sister beam forward of pawl bitt; renewed decking in way of the pawl bitt.
- Other: renewed anchor windlass support timbers; anchor windlass and gasoline donkey engine put in running order (San Francisco Maritime Museum 1959).

Fig. 9. *C.A. Thayer* undergoing hull plank replacement in Lake Union, Washington, in preparation for her delivery to San Francisco following her purchase by the California Parks Department.

Photo: Harold Huycke,
SFMNHP F16.35378n





Fig. 10. Heavy weather during delivery to San Francisco, 1957; looking aft along the main deck. Mainsail is being repaired.

Photo: Karl Kortum, SFMNH K9.38806n

- She was re-rigged, with new masts and bowsprit provided by the Spar Manufacturing Company of Seattle, Washington. Her old booms and gaffs were retained and sails were salvaged from the codfishing schooner *Charles W. Wilson*. A spanker sheet horse was taken from the schooner *Beulah* (Jones 1958). Masts were stepped and new rigging installed under the supervision of master rigger Jack Dickerhoff. Spike bowsprit and "bald headed" type masts of her original rig were replicated, but the mizzen sail was retained in the jib-headed configuration, without a mizzen gaff. The square foresail was not reinstated. Turnbuckles, rather than deadeyes and lanyards, were used at this point in the restoration (Olmsted 1972).
- The wheelhouse added during her codfishing days was removed, and her original wheelbox reconstructed. The brass wheel used in her later codfishing period was replaced by one of cast iron from the schooner *Azalea* (Jones 1958).

1957
Delivery

The *C.A. Thayer* was finally made ready for sea and sailed down the coast to San Francisco Bay in October 1957. A vivid account of this, the last voyage of a West Coast lumber schooner, is given in *The Schooner That Came Home*, by Harlan Trott (Cornell Maritime Press, Cambridge, Maryland, 1958).

1958
Haulout

A great deal remained to be done before the vessel was to be put on public display. In August of 1958, *C.A. Thayer* was hauled out at Moore Dry Dock

Fig. 11. Restoration of the roof of the aft cabin trunk, 17 July 1959. Preparation is underway for placing the vessel on public display.

Photo: SFMNHP B9.38802n

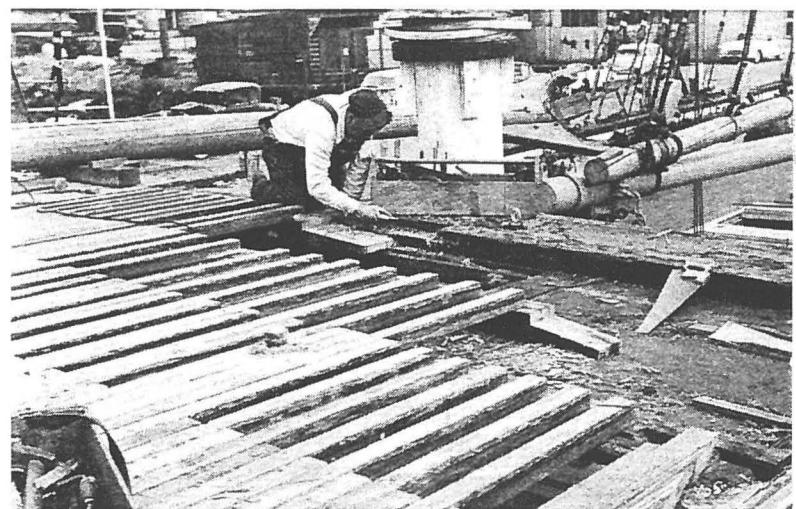


Fig. 12. *C.A. Thayer* at a restoration berth in Alameda, ca. 1960. Here she waits with paddle ferry *Eureka*, and steam schooner *Wapama* (beyond) to be shifted to the new San Francisco State Historical Park at Hyde Street.

Photo: SFMNHP B4.35775n



Company for more bottom work. A maximum hog of 8-1/2 inches was recorded in her keel at this time. The large steel gasoline and water tanks were removed from the hold and replaced by a more appropriate wooden water tank from the schooner *Beulah*. Research, restoration, and interpretation work continued in preparation for the vessel's public debut.

1959
Haulout

C.A. Thayer was again hauled out, this time at the Martinolich Ship Repair Company. The bottom was cleaned and painted, draft numbers painted, and 25 feet of keel shoe replaced (Martinolich Ship Repair 1959).

1960
Restoration of Aft Cabin

A detailed memorandum (San Francisco Maritime Museum 1960) was submitted by the San Francisco Maritime Museum to the Superintendent, District #4, California Division of Beaches and Parks, outlining the results of research into the original layout of *C.A. Thayer*'s aft accommodations, and providing plans which would guide the restoration of that space over the several years to follow. Information was gathered from conversations and correspondence with Capt. Ole Lee, who sailed as Mate on the vessel in 1915 and had command of her in 1918 and 1919. Photographs and plans of similar vessels in the collection of the Museum were also consulted. In the interest of visitor circulation, the passageway in the forward portion of the accommodation area was extended through to the after companionway. This plan (see figure 13, p. 23) reflects the configuration of the space in 1989.

1961
Haulout

In addition to routine cleaning and painting of the bottom, 50 feet of keel shoe was replaced and the mizzen crane iron was repaired.

1963
Placed on Exhibition

C.A. Thayer was finally opened to the public at the San Francisco Maritime State Historical Park at Hyde Street Pier in San Francisco on 2 October 1963, along with the steam schooner *Wapama*, the scow schooner *Alma*, and the ferryboat *Eureka*. She was interpreted with captions and labels developed by the San Francisco Maritime Museum (California Division of Beaches and Parks 1963).

1963-1979
Regular Maintenance

"The ensuing years were a struggle for both the ship and the State's crew because money and manpower were short and the collection—four wooden ships in total—was demanding. A period of cyclic maintenance was developed for *C.A. Thayer*, with haulouts in 1967, 1970, 1973, 1976, and 1979" (Hastings 1984).

1969
Haulout and Restoration

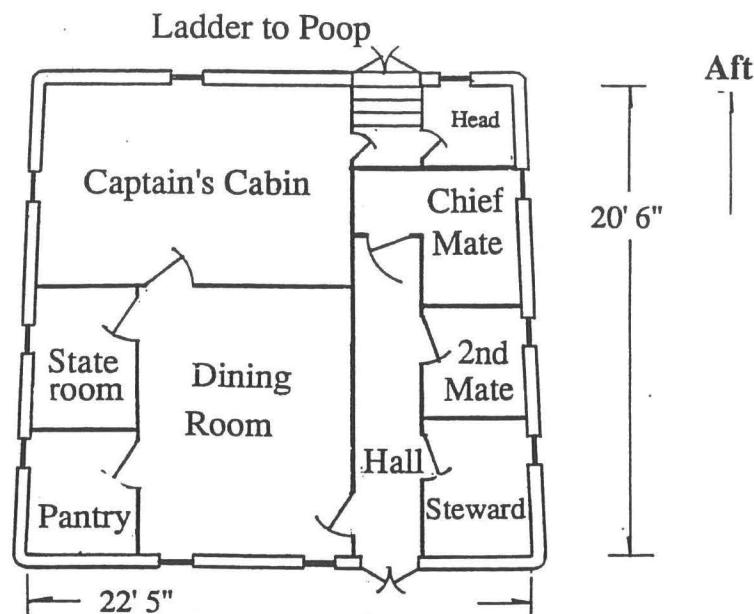
A photograph in Olmsted's *C.A. Thayer and the Pacific Lumber Schooners* is captioned, "...the whole stem is opened up in 1969..." The photo shows the vessel at Pacific Drydock and Repair Company with extensive planking removed and cant frames renewed in bows.

1972
Haulout

C.A. Thayer is hauled out at Merritt Ship Repair Company for cyclical maintenance and repairs (Golden Gate National Recreation Area 1972). During haulout at Merritt Ship Repair in Oakland, the keel is again measured, revealing a hog of 9-5/8 inches (Merritt Ship Repair 1972). Work performed included renewal of some bottom planking and repair of the windlass brake.

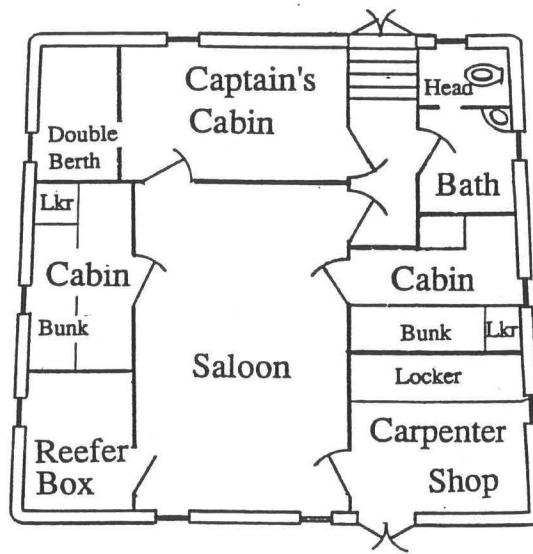
1975
Haulout and Repairs

C.A. Thayer is again hauled out at Merritt Ship Repair Company. Work included replacement of 367 linear feet of hull planking, renewal of the keel shoe, renewal of the forward deckhouse roof, and installation of a new galley stove and flue (believed to be the existing stove). Portions of



Arrangement in 1918,
as Recalled by Capt. Ole Lee

CABIN ARRANGEMENTS, C.A. THAYER



As Recorded in 1959



Present Arrangement

Fig. 13. Changes made in arrangement of the aft accommodations.

Graphic: D. Canright, Tri-Coastal Marine

the stern bull rail, caprail, and covering board were also renewed (Merritt Ship Repair 1975).

1977
Change of Ownership

In 1977, the State of California's fleet of historic ships, including *C.A. Thayer*, came under the management of the Golden Gate National Recreation Area, a newly-formed National Park. A Park Service report dated the following year states, "Last drydocking in 1972.... Rot is evident in upper third of mizzenmast" (National Park Service 1978).

1978-79
Leaking Accelerates,
Emergency Haulout

Harry Dring, Superintendent of Ships, in a memo dated 1 December 1978 notes that *C.A. Thayer* has been taking on water at the rate of 36,000 gallons over a six-day period, and requests an emergency haulout (Dring 1978). Merritt Shipbuilding Company submits a proposal to replace 150 feet of hull planking and to caulk an additional 400 feet of seams (Merritt Ship Repair 1978). The vessel was drydocked on 16 January 1979 and, in addition to the above work, 102 feet of keel shoe was replaced. A protective sheathing of plywood (pressure treated Chemonite) over Irish felt was applied to the entire underwater surface.

1980
Haulout and Survey

A survey was made by the firm of Lally, Hubnette, Jessie, Fay & Associates on 3 January 1980 as the vessel lay hauled out at the Merritt Shipyards in Oakland, California. Measurement of the keel showed 14" of hog (Lally, et al 1980). The survey notes extensive rot in the deck and in most of the upper frames, as well as in deck beam ends and covering boards. Evidence of worm damage and previous repairs is also noted.

1981
Removal of Mizzen Mast

During annual scraping of the masts in the spring of 1979, the mizzen mast was found to be severely rotten near the hounds. Further surveys found rot evident in the fore and main masts as well. For reasons of safety, the mizzen was removed from the vessel and a search initiated for new spars (Hastings 1984). The masts were ordered in 1982 from Intermountain Orient Co. of Boise, Idaho.

1981 and 1982
Damage in Winter Storms

A severe gale in January of 1981 parted *C.A. Thayer*'s stern offshore anchor chain, causing damage to 20 square feet of hull planks, on the starboard side at five feet above the waterline, as the vessel chafed against the pier. Another storm the following winter parted her bow anchor chain and stove in an additional eight planks amidships (Hastings 1983).

1983-1984
Refit

In the fall of 1982, the *C.A. Thayer* was hauled out at Pacific Drydock and Repair Company for repair of the hull damage sustained in the previous two years. Replacement of her masts and re-rigging was also scheduled. While removing the fore and main masts (the mizzen having been removed the previous year), the bowsprit broke off due to undetected rot, and its replacement was added to the project. The new spars from Intermountain Orient Co. were outfitted with the existing rigging and installed, along with new hemp lanyards. When hauled, the bottom was found to be fairly clean. Removal of several of the panels of plywood sheathing on her hull showed "no worm damage... in the protected areas" after three years (Hastings 1984). Storm-damaged and rotten topside planking was replaced on the starboard side, at the quarter and amidship. In all, 600 lineal feet of 4 inch thick planking, varying in width from 4 to 10 inches, was installed. The new planking was pressure-treated with wood preservative.

On 20 January 1984, *C.A. Thayer* returned to Hyde Street Pier. Surveys made

Fig. 14. Renewal of topsides planking, port quarter, frames 47 to 55, part of the preservation work completed in 1987.

Photo: Tri-Coastal Marine



by Hull and Cargo Surveyors and NPS staff identified "Extensive deterioration...in her deck beams, clamps, ceilings, and ribs. Her after deck-house...[showed] signs of extensive fresh water intrusion and a healthy infestation of dry rot fungus" (*ibid.*).

1987
Preservation Work

In an effort to slow the deterioration noted in previous condition surveys, preservation work was carried out on the topsides, main deck, and bulwarks (National Park Service 1987).

Work performed under contract with Richardson Bay Boatworks and Ways included:

- Refastening of twenty-three sprung topside plank butts;
- Replacement of 66 lineal feet of topside planking, port side;
- Selected recaulking of seams, and paying of seams with Hydroseal (a bitumastic sealant) on port and starboard topsides;
- Painting (black) of port and starboard topsides;
- Repair and replacement of deteriorated bulwark stanchions (repairs were made using cement and dutchmen, replacement stanchions were nonstructural);
- Installation of a bolster on the starboard quarter (for shifting of the stern mooring line to reduce hogging strains).

Work performed by NPS crew included:

- Replacement of two rotten deck planks, starboard forward;
- Selected recaulking of deck seams;
- Paying of all seams with marine glue (pitch).

1988-89
Emergency Haulout

In August 1988, *C.A. Thayer* began taking on water at a dramatically increased rate and an emergency haulout was planned.

C.A. Thayer was hauled out at Pacific Drydock and Repair Company in January 1989. The following work was performed:

- Renewal of 65 lineal feet of worm-damaged and rotten planking at, and just below, the waterline along starboard side, amidship;

- Removal of rudder and steering gear;
- Removal of all plywood sheathing along the waterline and ten additional sheet at various locations on bottom;
- Removal of keel worm shoe and installation of copper sheathing on bottom of keel;
- Relocation of sea suction thru-hull fitting from starboard to port side, new fitting and sea cock installed (National Park Service 1989).
- The keel was measured prior to haulout, and 14'-1/4" of hog was observed (Kossa 1988).

1989
Mizzen Boom Replaced

The mizzen boom, known to severely rotten, was unshipped and a new lathe-turned Douglas fir spar ordered in late 1987. The spar was outfitted with fittings and jaws from the old boom and was installed in 1989.

Fig. 15. *C.A. Thayer* at in her berth at the Hyde Street Pier, San Francisco, 1990.

Photo: Tri-Coastal Marine



■ Existing Condition

□ Summary of Condition

C.A. Thayer is presently afloat and open to the public at her berth at the Hyde Street Pier in San Francisco. She retains a high percentage of original fabric, but is in an advanced state of deterioration, the result of years of attack by dry rot, corrosion, and marine borers. Aside from the visible evidence of deterioration, her condition has not yet had a serious impact on her role as a historic display.

The most significant threat to *C.A. Thayer*'s long-term preservation is the dry rot decay seen in the major structural members of her hull and deck: ceiling, frames, keelsons, waterway timbers, deck beams, and deck planking. Survey has revealed many of these members to be in an advanced state of decay. A precise assessment of the extent and severity of deterioration will require partial disassembly of the structure for inspection.

Dry rot has resulted in the loss of watertight integrity in the topside planking and decks, a condition that increases fresh water leakage, thus accelerating the cycle of deterioration. Dry rot in the keelsons, ceiling, and frames has weakened the hull and increased "hogging," a distortion of the hull that is difficult to reverse.

In her present state, *C.A. Thayer* cannot effectively be preserved in an exposed environment. If she is to remain afloat, major structural repairs will be required to restore hull strength and watertight integrity. This would necessitate renewal of almost all decayed or partially decayed fabric; in effect, the majority of her hull structure.

□ Particulars

Documentation Number:	127 097
Registered Length:	156 ft. 0 in.
Overall Length (hull):	168 ft. 6 in.
Beam:	36 ft. 4 in.
Depth:	11 ft. 8 in.
Gross tonnage:	452
Net tonnage:	391
Year built:	1895
Builder:	Capt. Hans Bendixsen, Fairhaven, CA
Hull:	Douglas fir
Decks:	Douglas fir
Spars:	Douglas fir
Machinery:	Steam donkey engine in deckhouse
Rig:	Three-mast "bald-headed" schooner

□ General Arrangement

■ Construction

C.A. Thayer is constructed almost entirely of Douglas fir. Ironbark (a hardwood) is used in areas where chafe occurs, such as the corners of wood bitts, the inside of hatch coamings, and in the rig: gaff jaws, boom jaws, and trestle trees. The trunnels (tree nails), which fasten ceiling and hull planking, are of locust or oak.

The hull is carvel planked on double-sawn frames. Planks are fastened with a combination of iron ship spikes and trunnels. All major timbers in the hull, including keel, keelsons, deck beams, knees, clamp, and waterway, are held together with iron clench bolts or clench drifts. The ceiling is fastened with a combination of trunnels and clench bolts or drifts.

The hull was built using an adequate number of fastenings and long lengths of timber, most of which appears to be dense "old growth" timber. Some of the timbers, such as the waterways, are over 90' in length. Long scarf joints are used for joints in the major longitudinal members. All of these features contribute to form a hull of considerable strength and durability, qualities that have contributed to *C.A. Thayer*'s longevity.

■ Arrangement

C.A. Thayer has considerable beam for her depth of hold (36' versus 11'-8"), a characteristic that allowed her to sail with little or no ballast. The hull is shapely, with a fine entrance and a fair run. There is a considerable amount of deadrise (approximately 11 degrees) and sheer, though she has lost some of both due to upsetting of the bottom and hogging. The keel is without drag and the sternpost is set vertical to the baseline.

C.A. Thayer is a single-decked vessel, with the main deck extending from the bows to the transom, and forming the sole of the accommodations beneath the quarter deck. The main deck is enclosed by heavy bulwarks. There is a raised forecastle head forward, with the area beneath housing the anchor windlass. A deckhouse is located just aft of the forecastle head, in way of the foremast. The house, which underwent modifications as the vessel changed trades, now contains the galley, donkey engine room, bosun's locker, "watchman's room," and cook's cabin. During *C.A. Thayer*'s days as a lumber schooner, a crew's forecastle was located in the compartment now occupied by the bosun's locker.

There are two cargo hatches on the main deck, one located

abaft the deckhouse, the other abaft the main mast. The hatches also underwent modification during *C.A. Thayer's* working life; the after hatch (referred to as the "main hatch") has been lengthened, and the forward hatch is now little more than half of its original length (a third hatch, a small one originally located forward of the deckhouse, was decked over during her working period).

The accommodations area under the quarter deck contains the master's and officers cabins, and the saloon. The present arrangement of cabin bulkheads, the result of a restoration undertaken in the early 1960s, is a slight variation of what is believed to be the original arrangement.

The hull interior, which was originally one large cargo hold extending from the chain locker in the bow to the sternpost, now includes a "fisherman's forecastle" that was built into the forward end of the hold at the time *C.A. Thayer* became a codfisherman (an earlier version of this forecastle is believed to have been installed during her previous career as a salmon packer). The present forecastle dates from the post-WWII era and has been modified for museum use by opening up the aft bulkhead for public access. A companionway leading from the forecastle to the deckhouse has also been removed.

Small orlop decks are located in the forepeak, and at the aft end of the cargo hold. In terms of floodability, the hull is essentially a single compartment; there are no watertight bulkheads.

C.A. Thayer is rigged as a three-mast, bald-headed schooner. She was originally gaff-rigged on all masts, but the mizzen is now rigged for a leg-o-mutton sail, an alteration made in 1945. The bowsprit, at one time rigged with sprit and jibboom, has been restored to the original spike configuration.

□ Survey of Existing Condition

■ Survey Methodology

Survey of *C.A. Thayer* was performed using nondestructive techniques, with exception of core samples taken to determine the internal condition of selected hull timbers. Core samples were inspected for evidence of decay (a record of this data is given in Appendix 2, p. 89.). Condition of elements was generally assessed through visual inspection and sounding. Portions of the hull could not be inspected due to limited access. These include: approximately 90 percent of bottom planking (obscured by plywood bottom sheathing), most of the hull framing, floor timbers, keelson, and much of the bow and stern deadwood timbers. Nevertheless, sufficient data was collected to assess overall condition.

■ Organization of Survey Report

The following report of survey is organized by major elements (hull, deck, rig), and their component parts (planks, frames, etc.). For reference, components are sequentially numbered from forward to aft (i.e. frame #6 is the sixth from the bow). The measured scale drawings (located at p. 47) can be used to identify and locate components.

■ Survey Terminology

The survey contains standard terminology used for describing ships structure. The definition of these terms can be found in the *International Maritime Dictionary* (Van Nostrand Reingold 1961). The terminology used for describing condition, particularly the effects of rot and corrosion are not as well established. These are defined in the survey as follows:

- rot, rotten: primarily the effects of dry rot, several species of decay fungus known as Basidiomycetes
- decay, decayed: same as rot
- nail sickness: deterioration of wood in contact with corroding iron
- worm damage: damage to underwater hull by marine animals that eat wood, primarily *Limnoria triplacata* ("gribbles") and *Teredo navalis* ("ship worms")
- deterioration: loss of form and strength due to any of the above factors

■ Numerical Rot Rating

A rating system of 1 to 5 has been used in the survey in order to rate the various degrees of decay that were found in the vessel's wood structure.

- 1.0 sound wood
- 2.0 incipient rot is evident
- 2.5 softness, nominal loss of strength
- 3.0 decay is apparent, item retains at least 50% of strength
- 3.5 decay is advanced
- 4.0 decay is advanced, resulting in severe loss of strength, though item retains form
- 4.5 severe decay, no strength remaining, partial loss of form
- 5.0 totally decayed, partially disintegrated

■ Terms Used to Rate Condition

- severe: item is a preservation liability or safety hazard

- poor: item will require major preservation effort, i.e. repair or renewal
- marginal: item is at the point of becoming a preservation liability, more than routine maintenance will be required to correct deficiencies
- fair: item is not a preservation liability, though some deficiencies are seen; maintenance is required
- good: item requires only routine maintenance

■ Hull

□ Description

The hull is sheathed with 4" thick planking that varies in width from 6" to 18". The garboard is a heavier stave, measuring 6" in thickness. The double-sawn frames are 9" molded (nominal) and each futtock is 10" sided, forming frames that are 20" sided. Frame spacing is approximately 29-1/2" on center, a rather arbitrary dimension for which there is no explanation. The backbone of the hull is formed by the keel, and six keelsons: main keelson, rider keelson, and four "assistant" or "sister" keelsons. The hull interior is completely ceiled. The ceiling planks above the turn-of-bilge are 8" thick. Below the turn-of-bilge, the ceiling is lighter, measuring 3-3/4" in thickness.

□ Condition

Framing

The framing is concealed by the ceiling, and its condition cannot be fully assessed without extensive destructive testing. The methods used in the survey were limited to random core sampling, and visual inspection in the few locations where the frames could be viewed. Although these methods left much of the framing uninspected, enough information was collected to draw conclusions as to the extent and nature of decay in the frames.

Approximately 85 percent of the framing shows some degree of decay at the upper ends, in the area of the clamp and upper ceiling staves. This condition extends fairly consistently from the forepeak to the stern, though the frames under the quarter deck, port side, frame #53-59, appear in better condition. The probable cause for the general decay of framing in the upper hull is freshwater seepage through the deteriorated waterway timbers, covering boards, and topside planking.

The condition of the frames and floors in the lower hull appears no better; of the twenty core samples taken at or below the turn-of-bilge, only four revealed sound wood. These were at frame #4 in the forepeak (renewed in the 1960s), and frames #32 and #60 on the port side, in the hold. All other borings found soft and mushy wood fibers or totally disintegrated timbers. Visual inspections of

framing made during plank renewals over the last five years tend to confirm these results:

- 1989 Drydock—approximately two-thirds of the frames exposed during replacement of planks just below the waterline on the port side, between frames #20 and #35, were seen to be severely deteriorated, including lower futtocks and floors.
- 1987 Hull Repairs—removal of topside planking on the port quarter showed each of frames #49 to #55 to be partially deteriorated.
- 1983 Drydock—removal of topside planking on the starboard quarter, between frames #45 and #54 showed partial deterioration in more than half of the framing.

Areas of severe rot are also seen in the floor timbers below the forecastle sole, between frames #9 and #17, and at the aft end of the hold, at frames #58 to #60 port, and #48 to #51 starboard. A further indication of rotten framing is also noted in the sprung topside plank butts, particularly in the port side between frames #6 and #9. Here the curved planks have straightened as the fastenings can no longer hold in the rotting frames. The plank butts were refastened in 1987 by through-bolting them to the ceiling.

Planking

Condition of the hull planking can be summarized as poor above the waterline, and fair to poor below the waterline. With exception the planks replaced during repairs in 1983 and 1987, almost all topside planking shows evidence of dry rot damage, ranging from moderate to severe. Planking on the port side is in the worst condition, owing to sun exposure and prevailing winds. Here, many planks have deteriorated to the degree that the seams can no longer be effectively caulked and made watertight. As a result, driving rain enters the hull and promotes decay of framing and ceiling. An attempt to seal the topsides was made in 1987 by applying a bitumastic roofing tar (Hydroseal) to all deteriorated topside plank seams. This effort has probably helped to slow the rate of leakage and attendant deterioration, but is considered a stopgap measure; watertightness can only be achieved through renewal of rotten planking.

Dry rot was found in planking along the waterline in 1989, when plywood bottom sheathing was removed for inspection. This condition is believed to have been caused by entrapped rainwater, which entered along the upper edge of the plywood sheathing. As a result of this discovery, all sheathing was removed from the waterline area.

Bottom planking inspected during the 1989 drydocking showed moderate soft rot and local incidence of worm damage ("gribbles"). Severe worm damage on the port side, just below the waterline, was found to be the cause of the leakage which prompted an emergency drydocking.



Fig. 16. General decayed condition of upper frames as seen during hull repairs in 1987.
Note wedged trunnels in plank below opening.

Photo: Tri-Coastal Marine

Several planks in this area were subsequently replaced. A peculiar condition was noted when the damaged planking was removed—severe worm damage was seen on the inside of the bottom planking, indicating that gribbles were thriving in the bilge water inside the hull. A significant amount of worm damage was also found in the aft side of the stern post. Aside from these occurrences, worm damage was moderate after seven years in the water, thus indicating that the plywood sheathing has been largely effective.

Clamps

The clamps run from the stem to frame #57. They are single-thickness timbers in the midsection, between frames #16 to #57, but are laid up in two laminates at the ends. This was probably done to make it easier to fit them to the curve of the hull fore and aft.

Except in the area of the forecastle, the general appearance of the clamps is good, thus giving the impression of soundness. The problem is found inside and on the outboard face of these timbers, where widespread decay is seen.

The condition of the clamps in the forepeak is fair, with a

few rot pockets at deck beams, but becomes markedly worse as the clamps extend into the forecastle. Here, the port side is severely rotten (5) between frames #7 and #10, and behind most hanging knees. The starboard clamp is in better condition, though rotten (4) between frames #9 and #12. Cracks, possibly due to hogging stress, are seen in both port and starboard clamps. There is severe nail sickness at about 30 percent of the clamp fastenings. In the hold (frames #21-59) the clamp is consistently soft or rotten (2-3) along both port and starboard sides.

Ceiling

As with the clamps, the visual appearance of the ceiling generally belies its true condition. In the forepeak, the ceiling is in fair condition. Several soft or hollow-sounding areas were noted, indicating internal decay, and about 30 to 60 percent of the fastenings show nail sickness. The ceiling forward of frame #3 has been renewed with short lengths held in place by bolts and square washers. Borings taken in the ceiling at frame #4 revealed good wood on both port and starboard sides.

The forecastle ceiling above the sole has soft or rotten areas (2-3.5) throughout. The top five strakes are gener-

ally rotten (3-4.5) behind the hanging knees. Thirty to forty percent of the fastenings show nail sickness, about 10 percent of these being severe. Like the clamps, the ceiling on the port side of the forecastle is in worse condition than on the starboard side, particularly between frames #8 and #13.

Beneath the forecastle sole, the ceiling has become severely decayed due to poor ventilation and high moisture level. Despite the installation of open gratings in the forecastle sole, the space remains moist. All ceiling is soft on the surface. Nail sickness is seen in 80 percent of fastenings, and approximately 30 percent of the clinch rings are loose. The lower six strakes of ceiling are severely rotten or hollow-sounding (4-5) from frames #9 to #17, on both port and starboard sides.

The majority of the ceiling in the hold (frames #20 to #62) is sound on the surface but decayed inside or on the outboard face. Test boring verified this condition, with 60 percent of the borings showing decay in the outboard 4" to 6" of the strakes. Since the molded dimension of the ceiling is 8", this deterioration represents a 50 to 75 percent loss of structural material in the affected timbers. The actual reduction in structural effectiveness of partially decayed ceiling may exceed this due to undetected incipient rot, and loss of holding power of fastenings. Sounding of the ceiling with a hammer revealed hollowness in approximately 60 percent of the port ceiling, and 70 to 80 percent of the starboard ceiling. This indicates advanced decay on the interior, to within 2" of the visible surface of these timbers. On the port side, the upper four strakes are rotten (4-5) behind the hanging knees from frames #20 to #26. An area of surface deterioration and nail sickness is seen in the upper five strakes on the port side, between frames #34 and #41. The condition of the ceiling on the port side appears to improve aft of frame #54.

The worst area of decay in the hold is between frame #48 and #51 on both the port and starboard sides. Here the ceiling is rotten (4-4.5) and has disintegrated in places. The frames in way of the rotten ceiling are also badly decayed. The ceiling along the bottom of the hold is soft in several locations, and has scattered rot pockets.

Ceiling between the main deck and the quarter deck is rotten (4-5) on the starboard side at frame #51 (quarter deck bulkhead), and has been removed from frame #52 to the stern. The port side ceiling shows rot at the stern (frame #63), but is in good condition forward of this point.

Keel and Keelsons

The keel was inspected during haulout in 1989 and was found to be in generally good condition. Evidence of

previous worm damage was seen along the bottom of the keel when the worm shoe was removed. Other minor occurrences of worm damage were seen along the sides of the keel, though none are considered significant. Hog in the keel was measured at 14", with maximum hog at approximately frame #34.

Condition of the keelsons is less conclusive. Visual inspection of the rider keelson and the four assistant keelsons reveals soft areas on the surface and some rot around fastenings. Core samples indicate internal condition as follows:

- The rider keelson is in fair condition, except in the area below the fore and main hatches, where internal decay is seen.
- The upper assistant keelsons are in fair condition forward, but show internal decay in various locations in the midsection.
- The lower assistant keelsons show internal decay along the midbody, from frames #16 to #48.

Condition of the keelson itself could not be determined, as it is hidden by the rider and assistant keelsons. Further core sampling, or disassembly of structure, will be necessary to develop a more detailed assessment of the condition of the keel and keelsons, yet the data gathered to date indicates that overall condition is poor.

Conclusions

Collectively, survey data indicates that decay in frames, floor timbers, ceiling, clamps, and backbone members is extensive and advanced. This has resulted in an overall weakening of the hull, a condition which compromises watertight integrity and reduces the hull's ability to resist bending strains. The major implication of this condition is that a significant portion of the hull will have to be rebuilt in order to restore structural and watertight integrity. The deteriorated condition of the outer surface of ceiling presents a preservation dilemma—saving these historically significant timbers, while rebuilding strength into the hull, can only be accomplished with considerable effort and with use of preservation techniques that have not previously been used on this scale.

Main Deck and Deck Structures

Description

The main deck is constructed of 4" x 4" planking laid on single-piece deck beams measuring 11-1/2" molded x 14" sided. Beams that are 16" sided are located at the fore and aft ends of the hatches. The deck beams are supported at their ends by the clamps and hanging knees. Hold stanchions support the beams at the centerline, except in way

of the hatches. A 9" x 6" waterway timber runs from the stem to frame #61, port and starboard.

Condition

Deck Planking

The exposed portion of the main deck, extending from the forecastle head deck to the quarter deck bulkhead, is weathered and partially rotten in numerous locations. Deck seams continue to leak despite having been re-caulked and heavily payed with pitch in 1987. The worst conditions are seen aft, between the mainmast and the quarter deck bulkhead. General condition of planking is as follows:

- At least 50 percent of planking is hollow-sounding, indicating internal decay. Areas of severe dry rot and deterioration are seen.
- Bungs are missing and iron spikes fasteners are wasted in 10 to 15 percent of fastenings from deckhouse forward, and 35 to 40 percent from the aft end of the deckhouse to the quarter deck.
- Deep gouges and spongy wood are seen at numerous fastenings and butts. Many are filled with cement or pitch.
- Dutchmen (small wood inserts used for repair of rotten areas) are seen throughout, mostly at butts.

Deck beams in way of the main hatch are weakened and have sagged, causing rainwater to pool here, particularly on the starboard side. There are areas of severely rotten decking at the quarter deck bulkhead, port and starboard. Despite these problems, the main deck remains sound enough for foot traffic.

The areas of main deck under the forecastle head, quarter deck, and deckhouse are in fair condition with only minor

areas of decay seen in the planking. Two such areas are: a) under the quarter deck, just aft of the bulkhead, port and starboard, and b) the pantry in the deckhouse, under a leaking area of the overhead.

Waterway Timbers

The waterway timbers are internally decayed along most of their length, particularly between the forecastle head and the quarter deck. This is significant because the waterways are major longitudinal members of the upper hull. Long lengths of timber were used in the original construction in order to gain additional strength in the midsection of the hull. The existing starboard waterway is one piece from frame #15 to #52, a distance of over 90'.

The starboard waterway timber is internally decayed (3-5) from frame #11 to #52, and from frame #58 variously to its end at frame #61. The port waterway is very hollow (4-5) over short distances, between frames #4 and #6, frames #17 and #18, frames #35 and #36, and at the quarter deck bulkhead at frame #51. The few sections of waterway which sound solid are suspected of containing incipient rot.

Deck Beams, Knees, Hold Stanchions

Deck beams generally show advanced decay in those areas where the deck planking or waterway timber above are in poor condition. Much of this decay is in the beam tops and extends into the heart of the timber, thus creating a "hollow" beam which visually appears in good condition. Decay is most advanced at the beam ends and at carlings in the way of the hatches, areas where end grain is exposed.

In the forepeak, deck beams #1 and #2 are newer and in good condition. Beams #3 to #6, are visibly rotten or

Fig. 17. Main deck planking showing rotten areas at fastenings. Line of fastenings indicates location of deck beam beneath. Leakage in these areas has resulted in decay of decking and deck beams.

Photo: Tri-Coastal Marine



internally decayed at the ends. Beams #3 and #4 are very rotten (4-5) at the ends and beam #5 is rotten at the samson post partner. Deck beams #7 to #13 (in the forecastle) are all visibly rotten or internally decayed at the ends. Beams #8 to #13 are in fair condition where they run under the house, but are generally hollow and rotten from the house sills to their outboard ends. All deck beams under the exposed portion of the main deck, beams #14 to #33, are rotten at the ends, with the degree of decay ranging from moderate to severe (3-5). Several beams and half-beams at the hatches are rotten where they meet the hatch carlings. Beam #29, across the aft end of the main hatch, is of most concern due to rot at the starboard side of the hatch. The deck has sagged here and has been shored up. Half-beams #16 and #18 at the fore hatch, and half-beams #27 and #28 at the main hatch are decayed (3-4) at the hatch carlings. Beam #24, at the forward end of the fore hatch, has been repaired with a scarfed section and sister beam. The sister beam is now rotten along the top. Several beams are internally decayed or soft at locations inboard from the ends. These beams are #15, 21-23, and 30-33. The beams aft of the quarter deck bulkhead, #34-39, are in better condition, with only moderate decay at the ends.

Hanging Knees

Out of a total of forty-six hanging knees, forty show some degree of internal decay (2.5-5). Of these, eleven are hollow sounding or visibly rotten (4-5). These include the knee on the port side at beam #33, and knees on the starboard side at beams #17, 19-23, 26, 30, 32, and 34.

Hold Stanchions

Of twenty-one hold stanchions, ten stanchions are soft at the bases, and six stanchions are hollow-sounding or soft at the tops. Most of this deterioration is not severe at this time. The stanchion at beam #10 has a burned area near the forecastle sole, but still retains adequate strength. Stanchions at beams #8 and #11 are missing (these were probably removed when the forecastle was installed). The stanchion at beam #28, formerly the aft end of the main hatch, and at beams #14 and #15, forward of the fore hatch, were removed when the hatches were enlarged by the U.S. Army during World War II.

Fore Hatch

The fore hatch, which originally extended from deck beam #15-19, was reduced in length during the codfishing period and now extends from deck beam #17-19. The coaming is rotten (4-5) at the port aft corner, and soft along the deck edge. The port carling is very soft (4) around fastenings at beam #17, and the starboard carling is internally decayed (3-4) at beams #16 and #19. Most of the lodging knees are internally decayed. Port side knees

are internally decayed (2.5-3.5) at beams #15-17. Knees on the starboard side are severely decayed internally (4.5-5) at beams #15 and #17.

Main Hatch

The main hatch has also been altered. Originally located between deck beams #24 and #28, the hatch now extends aft to beam #29. The coaming is in fair condition with some softness along the deck line, and loose bungs on the after side. The port and starboard carlings are rotten variably (2-4), particularly in way of the half-beams. The most advanced incidence of decay is at the forward end of the port carling, where the timber is very hollowed out (4.5) at beam #24. The starboard side lodging knees at beams #25-27 are internally decayed (3-4). The removable hatch beams and gratings are in good condition. Despite the decay noted, the main hatch appears visually intact and remains reasonably sturdy.

Other Deck Structures

The covering board around the main mast has a rot pocket on aft side, and is soft on the forward side. The mizzen mast covering board has rot pockets in the port side. Both covering boards require proper bedding to the deck.

Conclusions

Although the main deck retains marginal strength for the present use of the vessel, it is no longer functioning as a watertight barrier; rainwater is entering through rotten deck planking and waterway timbers and contributing to the ongoing deterioration of the hull. In its present condition, the deck cannot be made watertight. Corrective measures would involve major renewals, including replacement of most of the deck planking and portions of the waterways. Some of deck beams, hold pillars, and hanging knees retain enough sound material to make preservation possible.

Bulwarks

Description

The bulwarks are supported by 8" x 10" bulwark stanchions and are topped with a 5" x 15-1/2" caprail. A 3-1/2" x 10" bulwark clamp is located on the inboard side to provide stiffening. The bulwarks are planked with 2-3/4" x 4" planking.

Condition

Many of the bulwark stanchions and large sections of bulwark planking are severely rotten or totally disintegrated. The starboard side appears in worse condition, probably due to the more direct exposure of sun and weather on the inboard side. All of the one hundred bul-

wark stanchions showed some degree of decay (3-5). Of these, twenty-three on the starboard side and fifteen on the port side are severely rotten or decayed inside. Much of this decay is old, as evidenced by numerous dutchmen and cement patches. In 1987, the disintegrated portions of stanchions were cropped out and repaired with cement, dutchmen, and in some cases, dummy stanchions. Exposed futtocks were filled with cement to the top of the waterway timber. These repairs are nonstructural and largely cosmetic. Though they help to reduce rain water intrusion into the hull below, they are temporary at best.

The bulwark planking is generally soft, with scattered areas of severe decay. Larger areas of severe decay are seen on the port side from frames #3-6, #17-22, and #41-50. The starboard side has a large section of severe decay between frames #13 and #21. The bulwark caprail was replaced in the 1960s and appears to be in marginal condition, with localized rotten or soft areas at the scarf, and signs of incipient rot along checks and at fastenings. A rotten area (4) is seen on the port side, under the halyard pad eye at frame #16. The starboard cap is rotten (4) in way of the fore chainplates at frames #15-17, and at a scarf at frames #22-23. The bulwark clamps are in fair condition except in way of the pinrails. Here, rot is seen on the inboard face, under the pinrail timbers. This condition was noted at the starboard forward pinrail and at the port and starboard main and mizzen pinrails. An additional rotten area (3-4) is seen on both port and starboard side, between frames #28 and #29. The bulwark clamps are generally rough with numerous splits and checks. A crack is seen in the port bulwark clamp at frame #12, and in the starboard bulwark clamp at frame #13. This condition, coinciding with cracks seen in the main deck clamps in the forecastle below, may be due to tension created by hogging.

Conclusions

Despite the poor condition of the bulwarks, they remain structurally sound enough for the present use of the vessel. The bulwarks cannot be properly maintained in their present state, and will need to be completely rebuilt. Until they are replaced, the rotten bulwark stanchions will continue to contribute to the deterioration of the hull. The decay in the bulwarks is evident to those visiting the vessel, and is the most obvious sign of the vessel's deteriorated condition.

Forecastle Head

Description

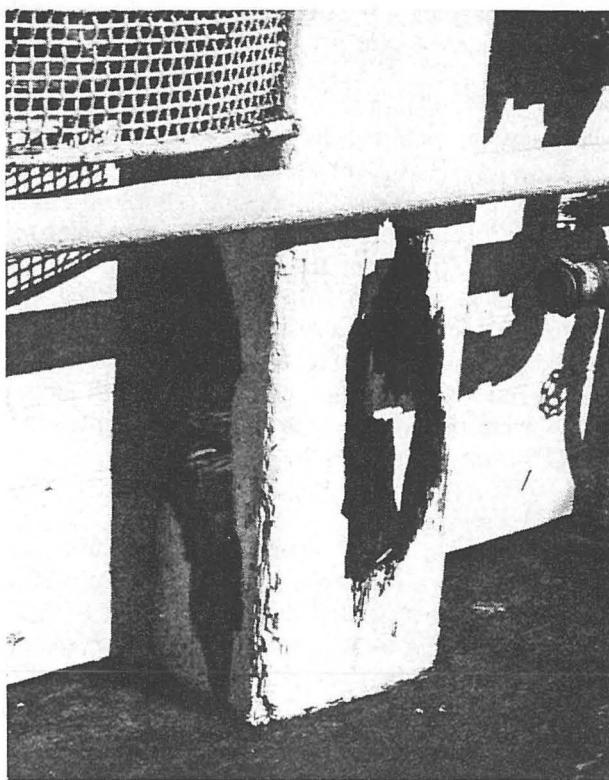
The forecastle head, the raised deck extending from the bow to frame #6, is enclosed by a low bull rail (9" x 10") port and starboard. The catheads, capstan, a samson post,

and two single wood bits are mounted on this deck. The cross head for the windlass hand pump is mounted just forward of the samson post. The forecastle head is planked with 4" x 4" planking laid on a series of five deck beams. The deck beams are supported at their ends by clamps which are a continuation of the bulwark clamps.

Condition

Forecastle head planking was renewed in 1957, and is presently in good condition, with no visible signs of decay. The pitch in deck seams is weathered, cracked, and in need of re-paying. Deck beams are sound except at the ends where beam #4 is rotten (4) at the port end, and beams #2-4 are rotten (3-4) at the starboard ends. The clamp is rotten (4-5) on the port side at beams #4 and #6, and has rot pockets (3) on the starboard side at beams #2-4. Both log rails are internally decayed (3) at the after ends and aft of the catheads, and there are soft spots (3) under the mooring chocks that are mounted on top of the log rail. The covering board (under the log rail) on the starboard side is soft (3.5) at the forward end. The blocking, above the deck at the bow, is hollow-sounding just forward of the forestay anchors. The samson post is soft along a check on the forward side above the forecastle head, but is otherwise in good condition. The port wind-

Fig. 18. Typical condition of bulwark stachions prior to preservation work in 1987. Photo: Tri-Coastal Marine



lass partner timber, on the underside of the deck, is rotten (5) between beam #4 and the samson post. The wood bitts are sound. Both catheads show incipient rot in checks on the top. The capstan is in good condition, and the wood base it sits on is checked, but otherwise sound.

☐ Conclusions

The forecastle head deck and appurtenances are in fair condition relative to most other areas of the vessel. Decay has not yet advanced to the point where the structure can no longer be maintained. The deck seams should be payed and other seams sealed to prevent fresh water from getting into the structure and causing decay. Treating rot-infected areas with nontoxic wood preservatives will help to stop the spread of decay in the catheads, log rails, covering boards, and deck beams.

■ Deckhouse

☐ Description

The deckhouse is located on the main deck, just abaft the forecastle head, between frames #9 and #23. The house has been lengthened (it probably originally extended no further aft than frame #20) and it is not certain which, if any, portions are original. The forward end of the house is occupied by a boatswain's locker, aft of which the galley, pantry, and cook's cabin are located. The aft end of the house is taken by the donkey room, which houses a steam donkey engine and boiler (a post-historic addition). The boatswain's locker and galley are accessed by sliding doors on the forward and port sides. A large double sliding door provides access and ventilation to the donkey room. A wood water tank (port) and an iron tank (starboard) are placed alongside the house.

The house top is presently sheathed with fiberglass cloth (it was originally canvas covered). The foremast is stepped through the house top, and a small boat is stowed to starboard of the mast. The house rests on a heavy timber sills and is sheathed inside and out with horizontal tongue-and-groove sheathing.

☐ Condition

House Exterior - Sides

The sill is rotten or soft variously all around. The forward sill is rotten along the bottom from centerline to starboard, and at the port end. The starboard side sill is internally decayed (3-4) all along, and the port sill is moderately decayed (2) with a rotten area (3.5) at the aft end. The aft sill is rotten (4) at the port and starboard ends. All four corner posts are soft or rotten (3-4) at the lower ends, with the after two being in the worst condition. There are scattered rotten or soft areas in the tongue-and-groove

sheathing, except on the aft side of the house where the sheathing it is intact. These decayed areas are generally located at butts, near the corner posts, and in the top and bottom planks of sheathing. All windows are in good condition except for windows #1 and #2 on the port side, where the window sills are soft (2.5). The port side door has a rotten area (4) in the upper righthand corner. The other two exterior doors and frames are in good condition. The port and starboard skylights have small rot pockets in the inside. The glass panels area broken in both skylights, and the starboard skylight cover has loose hinges with screws missing.

The wood water tank on the port side has rot in the tank ends, in the bearers, and at variously locations on the staves. The iron straps around this tank are corroding. The iron tank to starboard is corroding and in need of protective coating.

House Exterior - Top

The house top overhang is decayed variously all around the house. The aft side overhang is rotten (3-5) at the port and starboard ends. The port side overhang is soft at the forward end and rotten (3-4) between windows #3 and #4. The starboard overhang has a rotten area (5) extending from 6' to 20' aft of the forward end of the house. The forward side overhang is in fair condition with one soft area (3) at the port end. The covering boards on the house top have rotten areas (3-5) on all sides, with the port side being the worst (4-5), particularly at the aft end. Gaps were seen under the covering boards at various locations, indicating that water gets beneath them and promotes decay in the house top. The fiberglass deck covering is cracked and leaking in several areas. The covering boards around the foremast appear to be soft beneath the fiberglass. The forward outboard chock for the small boat is creating a water trap which could be contributing to decay in this area.

House Interior - Boatswains's Locker

Decay is seen in several areas of the overhead, including a rot pocket in the starboard end of the #1 house top beam, and a rotten section of decking (3) at the port forward corner. The header under the house top is internally decayed (3) all around. Overhead blocking forward of the galley bulkhead is rotten (4).

Galley

The overhead is rotten and leaking over the galley stove, around the stove pipe. The wood burning stove is in good condition and is operable.

Pantry

The overhead has two rotten planks (4-5) on centerline

near the pantry bulkhead. There is a severe rot pocket (5) in the main deck below the rotten area in the overhead.

Cook's Cabin

This compartment appears in good order, with no signs of leakage from the overhead.

Donkey Room

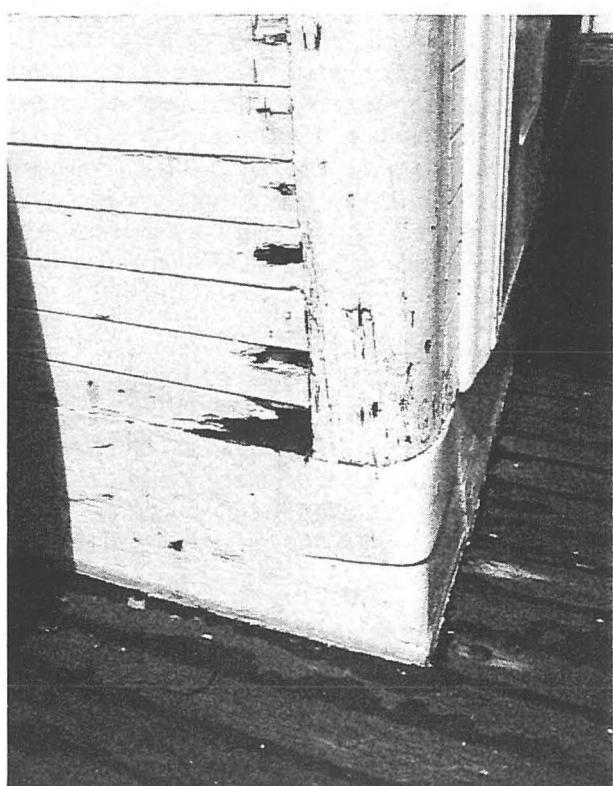
The main deck is soft (2-3) at the aft corners, port and starboard. The donkey engine and boiler are well coated, with only minor evidence of corrosion.

Conclusions

The top and sides of the deckhouse will need to be rebuilt in order to prevent further deterioration due to freshwater leakage. The major task will be renewal of the sill timbers that the house rests on. This will require lifting or shoring up the house. If major renewals to the main deck are undertaken, the entire house will have to be removed from the vessel.

Fig. 19. Port aft corner of deckhouse; rot at the ends of tongue-and-groove sheathing and at base of corner posts. The massive sill timber beneath is also partially decayed at corners.

Photo: Tri-Coastal Marine



■ Quarter Deck

■ Description

The quarter deck extends from the bulkhead at frame #50 to the stern. A raised trunk occupies most of this deck, and provides full headroom for the aft accommodations. Access to the accommodations is via double doors in the port side of the quarter deck bulkhead, and a sliding companionway in the aft end of the trunk. A skylight is mounted on the trunk top. The trunk top decking is varnished and payed with white window glazing compound. The helm, a patented steering gear in a wooden wheelbox, is aft of the trunk. Pairs of large wood bitts are mounted port and starboard, in way of the wheelbox. The quarter deck is enclosed by a low bull rail and a taffrail with turned wood stanchions. A pair of iron davits are mounted over the stern.

■ Condition

Quarter Deck Planking

Approximately 70 percent of the deck planking appears to have been renewed in the post-historic period. Scattered areas of rot are seen. On the port side, in way of the trunk, planks are internally decayed at quarter deck beams #1-3. Planks are rotten forward of the wheelbox, at frame #61. The planks here are sprung up, indicating some movement of the stern due to hogging. The plank butts along the starboard side of the quarterdeck bulkhead, and along the aft end of the trunk, appear to have no caulking. Signs of incipient rot are seen in these locations. The outboard margin plank is rotten (4) on the starboard side at frame #61.

Quarter Deck Beams

The quarter deck beams in way of the trunk are short sections extending from the trunk sill to the quarter deck clamp. The port side beam at frame #51 is severely rotten (4.5) from the trunk sill to the clamp. The starboard side beams at frames #51 and #53 are rotten (3) at the outboard ends, and beams #54 and #56 show evidence of old decay (3-4) and have been sistered. The full-breadth deck beams aft of the trunk are in generally poor condition. The beam at frame #60 (at the aft end of trunk) has a rotten area (3) at the starboard outboard end, and has been sistered at the centerline. The beam at frame #61 (at forward side of stern post) is rotten (4) on top, in way of the sternpost, and is hollow sounding at the starboard end. The beam at frame #63 (at aft side of rudder trunk) is severely rotten (4.5) in way of the rudder trunk, but has been sistered and is structurally adequate.

Quarter Deck Clamp

The quarter deck clamp is rotten along much of the star-

board side. Rotten areas (3-4) are seen at frame #51, 54-58, 59, and 63. There is internal decay at frames #52 and #53. The port clamp could not be viewed along much of its length due to interior ceiling, but was seen to be sound from frame #57 aft. The top 3" of the port clamp has been repaired with an insert between frames #59 and #61. This method of repair is inadequate, as it does not restore full strength to the clamp.

Quarter Deck Covering Board

The covering board shows decay in numerous locations. The port covering board is rotten (4) at the scarf at taffrail stanchion #4, and is internally decayed (3) at stanchions #5 and #6, and under the chock at stanchion #8. The starboard covering board is internally decayed at stanchion #1, and at a butt at stanchion #6. Incipient rot was seen on the outboard edge, between stanchions #2-5. Across the stern, the covering board is rotten (4) at the starboard end.

Bull Rail and Taffrail

Rot in the bull rail and rail cap appears to follow the pattern of the rot seen in the covering board beneath, indicating the spread of decay from one member to the other. The port bull rail sounds hollow (3) at a scarf at stanchion #1, under the chock at stanchion #8, and at stanchion #9. The starboard bull rail is rotten (4) at a scarf at stanchion #1, and internally decayed (3) at stanchions #2-6. Across the stern, the bull rail is rotten (4) at the starboard side, and soft (2) at the port davit. The cap, which rests on the bull rail, is rotten (4) at stanchion #6 on the starboard side, and at a scarf at stanchion #1 on the port side. Incipient rot was seen in the cap across the stern. Turned taffrail stanchion #7 on the port side is soft (2) at the base. Across the stern, stanchions #1 and #2 from starboard are rotten (4) at the bases. The post at the forward end of the starboard rail is rotten (4). This is considered a priority item because the jigger tackle for the mizzen boom lift is secured to the post. The taffrail has rotten areas at stanchions #5 and #6 on the starboard side, and scattered areas of incipient rot (2.5) across the stern.

Cabin Trunk

The cabin trunk has scattered areas of decay much like the deckhouse, but appears to be in better overall condition. The trunk sill is rotten (4-5) at the starboard aft corner. Soft or rotten areas are seen at frame #51 and #59 on the port side, and at frame #52 on the starboard side. The sill across the aft end of the trunk is soft (2) all along. The corner posts at the forward end of the trunk are rotten (4-5) and the starboard aft corner post is rotten (3.5) at the base. The post at the port aft corner is sound. The tongue-and-groove sheathing on the sides of the trunk is rotten in

numerous locations. The bottom stake of siding is rotten (3-4) all the way around. This condition will eventually contribute to rot in the sill timbers. Other areas of rot are found primarily at windows and at corners. The aft companionway hatch is soft (2.5) at open seams. An interior panel on the port side, just inside the companionway, is rotten (3.5) along the bottom. The sliding cover over the window of the Second Mate's cabin, port side, is severely rotten (5) and the covers at the Chief Mate's cabin and head are soft (2-3).

The planking on the trunk top is generally in fair condition, with minor rot pockets and signs of incipient rot. Many of the bungs appear to have lifted slightly out of their holes. The cause and significance of this condition is not known. About 20 percent of the butts show incipient rot, and the putty or marine glue in the seams is cracked, resulting in leakage into the accommodations spaces below. The skylight on the trunk top is in good condition, except for a small area of rot (3) at the base of the port after corner post.

Quarter Deck Bulkhead

The quarter deck bulkhead is in generally poor condition. The sill that forms the base of the bulkhead is rotten (2-4) all along the bottom, and severely rotten (4.5) on the starboard side. The exterior tongue-and-groove sheathing is severely rotten (4-5) in numerous locations, particularly on the starboard side. The top and bottom stakes of sheathing are rotten along the starboard side. Several sheathing stakes are rotten inboard and below the starboard hanging knee, and there is an area of rotten sheathing below the port bulkhead window. The port hanging knee is soft (2.5) at the upper end. The paneling on the underside of the trunk top overhang is rotten (5) at the port side and over the accommodations access way.

Conclusions

The quarter deck and associated structures require a considerable amount of repair to return them to a maintainable condition. Decay has already progressed to the point that joints and seams cannot be made watertight without replacing rotten material. The exception to this is the trunk top which should be caulked to prevent further water damage to the aft accommodations.

Aft Accommodations

Description

The aft accommodations are abaft the quarter deck bulkhead at frame #50, and extend to the aft end of the trunk at frame #60. This space is divided into several compartments. The accommodations include a saloon and

Captain's cabin on centerline, the Second Mate's cabin, Chief Mate's cabin, and head on the port side, and a pantry and spare cabin on the starboard side. Aft of the accommodations, is a lazarette which extends to the stern. The interior of the saloon and Captain's cabin are panelled with imitation wood-grain panelling. All other interior spaces are sheathed with tongue-and-groove. The overhead is paneled throughout.

Condition

Second Mate's Cabin

This compartment is unfurnished, but contains interpretation panels. The interior sheathing across the forward bulkhead is soft or rotten (3-4) at the lower ends on the port side. Sheathing along the cabin trunk is soft (3) at the lower ends. The cabin door is loose on its hinges.

Mate's Cabin

This cabin is also unfurnished. The window frame is soft at the bottom. Signs of seepage were seen under the clamp at frames #54-55, and under the outboard edge of the cabin trunk top, between frames #55 and #56.

Head

The window frame is soft (2.5) along the bottom. Interior sheathing is rotten (4.5) at the outboard corner over the watercloset. The main deck, in the enclosed area behind the watercloset and outboard of the trunk, is soft on the surface, and covered with wood shavings and debris from previous repairs. Water stains (indicating seepage through the cabin top) are seen over the sink.

Saloon, Captain's Cabin, Spare Cabin

These compartments are in good condition, and are furnished and dressed. Water stains on the overhead paneling indicates seepage and possible rot in the overhead. The cabin trunk top beams could not be viewed due to the overhead paneling. The condition of these beams is not known.

Lazarette

The lazarette is an empty and unfinished space. This compartment is not accessed on a regular basis and dirt and debris has accumulated. The lazarette bulkhead at frame #59 has a rotten area in the sill on the port side, and a rot pocket in the sheathing near the port clamp. The mooring chock and anchoring plate (for the stern anchor) are rusting and in need of coating. The coaming of the lazarette access hatch is severely rotten (5) on the aft side. The condition of the hull and stern structure viewed in the lazarette is discussed in the survey section on the hull.

Conclusions

The overall condition of the aft accommodations is fair,

with most of the deterioration apparently dating from a previous period. The main concern is this area is the chronic leakage in the trunk top that will result in water damage to the interior finishes and furnishings. The leakage is believed to be due to the use of window glazing compound in the seams. A more flexible material should be substituted.

Rig

Description

C.A. Thayer's rig is a replication of her original rig, with exception of the leg-of-mutton mizzen. The masts and bowsprit date from 1983, when the vessel was re-rigged, replacing spares installed in 1957. The gaffs and booms date from the late 1950s, or later. The mizzen boom was replaced in 1989. The wire standing rigging, most of which dates from 1957 or later, is set up with deadeyes and lanyards. Much of the running rigging is rove off, including the halyards, lifts, and some of the sheets. The gaffs and booms are painted a buff color, the masts and bowsprit are oiled.

Condition

Bowsprit

The bowsprit remains in good condition. Open checks and knots on the upper surface of the bowsprit may promote decay and should be filled with preservative. The service on the headgear rigging is in good condition and well-tarred.

Foremast

The foremast is in good condition with no signs of decay. The trestle trees are sound but are cocked to starboard about 5 to 10 degrees. The fore boom is sound. A soft area is seen in the fore gaff, on the starboard top, at approximately mid-length. The standing rigging is in fair condition, though some corrosion was seen, particularly on the port shrouds. All service is generally fair condition. The lanyards (four-strand hemp) are in good condition, though undersized. The ratlines are sound, but some of the seizings are of questionable integrity. The lowest starboard ratline is missing seizings. The service is rotten under the forestay leather, and the parcelling on the fish tackle pendant is deteriorated. The sheet and halyard blocks have recently been overhauled, and the fore halyards replaced with new manila. The condition of the gantline blocks is not known.

Mainmast

A rot pocket is seen on the forward port side at the hounds. Rot pockets were also seen at the spring stay band, and in the mast section above. The trestle-trees are sound but

badly checked on the starboard side. The cross-trees show rot around the fastenings to the trestle. The mast below the trestle-trees appears in good condition, though further down the mast, the boom table is rotten and 2 wedges at main deck are rotten on the forward side of the mast. These items may eventually promote rot in the mast itself. The main boom is in good condition. The gaff shows rot pockets half way out on the starboard side, and outboard of the inner peak halyard band. There are deep checks on the top of the gaff, and the outermost band is loose.

The standing rigging is much the same as the foremast. The port shrouds and the starboard backstay are corroded, with some surface wires almost wasted through. The service and parcelling at the eyes is partially rotten.

The running rigging is in the same condition as that of the foremast.

Mizzenmast

No rot was seen in the mizzenmast, though there are rotten mast wedges at the main deck. The trestles and cross-trees are sound but are rather poorly fit up. The boom table is rough but sound. The upper band for the lift crane is a poor fit and has cocked on the mast. The mizzen boom is in good condition. The mizzen standing rigging and service is in generally better condition than the fore or main, while the running rigging is about the same.

Conclusions

Overall, the rig is in good condition and requires only routine maintenance. It is relatively new and contains no historic fabric, with the possible exception of some iron fittings and one or two of the shrouds. An effort should be made to treat rot pockets and rot-prone areas with wood preservative, and to protect all standing rigging from further corrosion. All rotten mast wedges should be replaced to prevent the spread of rot to the masts.

Electrical System

Description

C.A. Thayer's electrical system is a 110/220 VAC shore-power system that was installed in 1960s for museum use (the system is shown in California Division of Beaches and Parks drawing no. 434-100, dated 1960). Many alterations and repairs have been made to the system over the years. The system includes circuits for lighting and service outlets, and a 220 volt circuit for the electric bilge and fire pump in the forepeak.

Condition

The electrical system has been recently upgraded to correct many deficiencies which posed immediate threats to

the vessel, visitors and staff. All extraneous and unused wiring and circuit breaker boxes have been removed. Conduit and wiring has been upgraded to acceptable marine standards.

Conclusions

The existing electrical system no longer poses a serious and immediate threat to the vessel and those aboard her. The system has been brought up to the Uniform Building Code by correcting all deficiencies (small business contract CX8520-0-0006).

Piping System

Description

The piping system consists of a fire and bilge system, with provision for hosing down the main deck. There is a single electric pump (1-1/2" x 2") with two bilge suctions, and a single sea valve providing sea water for the fire system. The fire system is also connected to a fresh water supply from the pier. Piping is a combination of galvanized iron and PVC.

Condition

The piping system is in generally good condition. The through-hull fitting and sea valve were replaced in 1989. The bilge and fire pump shows signs of leakage, but is otherwise functional. All piping appears adequate.

Conclusions

The fire and bilge system is considered adequate in terms of condition. The bilge pumping capacity of the 1-1/2" electric pump is minimal for a vessel of *C.A. Thayer's* size. Upgrading to a 3" pump, with two additional bilge suctions, should be considered.

Machinery and Equipment

Description

C.A. Thayer's machinery is limited to a donkey engine, and steam-powered pump. Equipment includes anchor windlass, hand pump, and steering gear. All of the items are historical.

Condition

Windlass: The windlass is believed to be original. It appears to have been power-driven at one time during the vessel's later working career. Portions of the power take-off (gears and belts) are now gone, but the windlass remains manually operable. The windlass is corroding due to inadequate protective coatings. The cross head (on the forecastle head deck) is cracked and rusted, but is still operable. The clutch mechanisms are frozen and inopera-

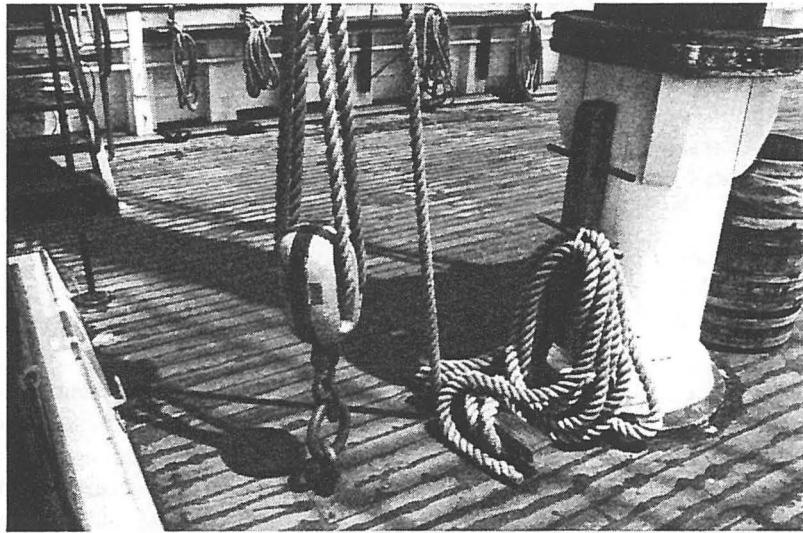


Fig. 20. Mainmast and fore sheet. Rig is in good condition, with new running rigging rove off in 1989.

Photo: Tri-Coastal Marine

ble due to years of corrosion. The cast iron chain pipes below the windlass are severely corroded.

Deck Pump: The deck pump is a small cast iron hand pump located on the main deck in way of the mizzen mast. It is not original, but was installed during the historic period to replace the pump that was originally located aft of the main mast. It is inoperable, and is suffering from corrosion due to insufficient protective coatings. The pump suction pipe, originally extending down to the bilge, has been removed.

Steering Gear: The steering gear is believed to be original equipment. It is presently out of the vessel and is undergoing preservation. Prior to its removal, the steering gear was rapidly corroding due to leakage in the top of the wooden wheel box. The steering shaft has been welded so that it can no longer turn freely.

Donkey Engine: The donkey engine, including a vertical fire-tube boiler and a two-cylinder steam winch, is located in the aft compartment of the deckhouse. It is not original to the vessel (though a similar donkey engine was originally located here), but was salvaged from the hulk of the schooner *Beulah*.

The donkey engine is in fair condition for an industrial artifact. Light corrosion is seen at various locations, though none is severe at this time. The donkey engine is not operable and the internal condition of the boiler and steam engines is not known. The entire assembly is

mounted to an I-beam foundation that is simply resting on the main deck—it does not appear to be secured (a donkey engine could not have been installed in such a casual fashion when the vessel went to sea).

The installation, begun in the 1960s, was never completed, as there is no piping for the boiler and the drive system for the power winch (on top of house) is nonexistent.

Steam Pump: The steam pump is a small single-cylinder horizontal steam engine that is mounted in the deckhouse, to port of the donkey engine. It was also taken from the schooner *Beulah*. The steam pump is in good condition, but like the donkey engine, the installation is not complete; there is no steam or water piping.

Conclusions

The windlass and hand pump (machinery that is exposed to the weather) are continuing to corrode at a rapid rate, resulting in permanent damage to significant fabric. They should be protected with anti-corrosive coatings as soon as possible to prevent further damage.

The steam pump and donkey engine are in a semi-protected environment and are not presently at risk. The installation of these items should be completed, based on thorough research, in order to improve their historic authenticity. The steering gear should be made operational by freeing up the shaft. This will allow the gear to be rotated for lubrication.

■ Assessment of the Significance of Fabric and Features

□ Background

C.A. Thayer has been accorded national significance as one of the last remaining examples of the Pacific Coast sailing lumber carriers of the latter period of the 19th century. She was made a National Historic Landmark in 1966 and was subsequently placed on the National Register of Historic Places (National Park Service 1978). She was judged to be significant in the areas of commerce and industry. Along with her sisters in the lumber trade, *C.A. Thayer* made a major contribution to the development of the Pacific Coast of the United States by delivering the lumber from mills along the coast of northern California and Oregon to builders in San Francisco and Los Angeles.

□ Purpose and Methodology

The “significance” of the various elements of *C.A. Thayer*, whether they be fabric or features, refers to the degree to which they contribute to the overall historic significance of the vessel. A nonsignificant element would be one that does not contribute, or that detracts from overall significance. The assessment of significance should serve to:

- Ensure that future treatment preserves the integrity of significant elements, while eliminating or reducing the impact of nonsignificant elements.
- Focus documentation efforts on significant, rather than nonsignificant, elements.
- Allow a more representative and informative interpretation of the vessel.

□ Rating System

The significance of the individual elements of *C.A. Thayer* have been rated according to the following definitions. These definitions correlate with the “historic treatment rating” system of the Inventory Condition Assessment Program (ICAP) developed by the National Park Service. (The ICAP system specifies the range of acceptable treatments for each rating level.)

Highly significant (ICAP Rating 1-2): elements which were incorporated in the vessel’s original construction, or which date from her period as a lumber carrier (1895-

1912). At the top of this list are prominent features and fabric that are major contributors to the historic character of the vessel.

Significant (ICAP Rating 3-4): elements that have undergone repair or replacement, but retain their original form; also, additions or alterations made during *C.A. Thayer*’s later working periods as a salmon packer and codfisherman (1912-1950).

Nonsignificant (ICAP Rating 5-6): additions or alterations made after *C.A. Thayer*’s working career (1950 to present) that are not known to be characteristic of the vessel or her type.

Information on the origin and present state of fabric and features is taken from physical history research and from the survey of existing condition.

□ Rating of Elements

The following elements are rated in descending order of significance. A distinction is made between features (elements of design and construction), and fabric (physical elements: planking, masts, etc.). A general assessment of condition is given for each element, along with comments on the factors that affect their significance.

■ Highly Significant Features

Hull Design: *C.A. Thayer*’s hull shows well developed lines, the product of a half-model from which at least fifteen hulls were built (Olmsted 1972). The hull shape reflects the requirements of the lumber trade: the ability to load bulky cargo and to sail with little or no ballast. In a broader sense, the hull typifies the larger American coasting schooners (over 300 tons) that were built on both the East and West coasts during the latter half of the nineteenth century. Only one other such hull is afloat today, a near-sister, *Wawona*.

The hull largely retains its original form, although progressive hogging has upset the midships bottom, flattened out the sheer, and caused a drooping of the stern. The significance of *C.A. Thayer*’s hull form warrants efforts to arrest hogging and, where possible, to correct or reduce distortion in the course of future repairs.

Method of Construction: The method of construction of the hull is highly significant as an example of superior wooden shipbuilding. The long lengths of high-quality Douglas fir used in *C.A. Thayer*’s construction, and the precision with which the structure was assembled, are features of a well-built wooden vessel. These features are largely responsible for the vessel’s longevity. Examples of

some of the longer timbers include:

main deck waterway	90 ft.
ceiling	80 ft.
keelsons	95 ft.

Most of the important structural members of the hull are dense "old growth" timber that is generally free of large knots. This indicates that a great deal of selectivity was used in the choice of material, even considering the abundance of high-quality timber available at the time of her building.

The method of fastening, including clench bolts (as opposed to threaded bolts) and trunnels (tree nails) is significant as an example of American shipbuilding practice of the period.

An effort should be made to preserve *C.A. Thayer's*

method of construction by making all replacements and repairs using materials of equivalent dimension and quality, and by duplicating the precision of the original assembly.

General Arrangement: General arrangement refers to the placement of major elements (bulkheads, hatches, and cabins). *C.A. Thayer's* arrangement is somewhat altered from that of her most significant historic period, and therefore does not fully reflect the arrangement of a lumber carrier. Some features, such as the aft accommodations area, have been restored to reflect this period, although minor changes have been made to facilitate visitor access (see Fig. 11). Other features, including hatches, deck house, and hold, are altered to the point that they impact the integrity of the original arrangement. Some of these alterations are significant as products of later historic

Fig. 21. Fisherman's forecastle, starboard side looking forward. The forecastle is a significant feature of the codfishing period.

Photo: Tri-Coastal Marine



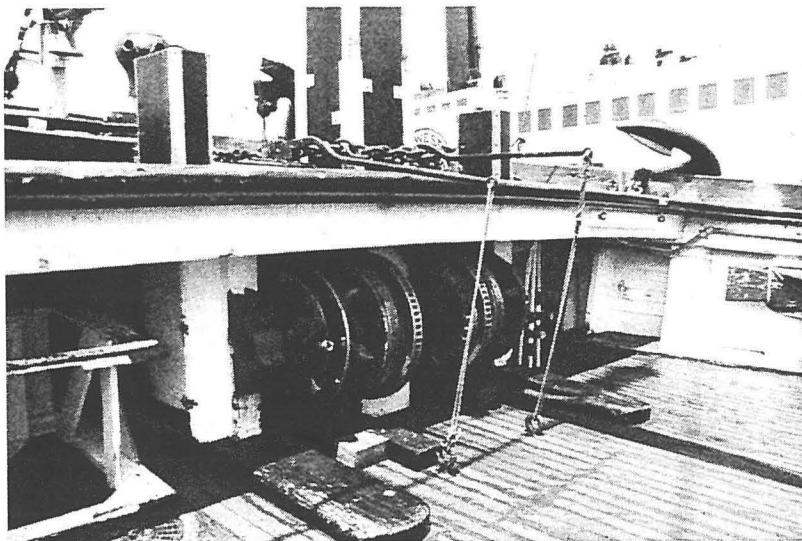


Fig. 22. Anchor windlass beneath forecastle head, looking forward on the port side.

Photo: Tri-Coastal Marine

toric periods. Reversal of all alterations is not recommended. However, some corrections, such as returning the fore and main hatches to their original dimensions and restoring the deck house to its original layout, would improve historic integrity without sacrificing significant features of later periods.

Rig: *C.A. Thayer's* rig is a reconstruction of her original rig, based on photographs and oral histories. Although the rig contains no historic fabric, its form is considered highly significant as the only intact example of a West Coast three-masted schooner rig. Historic integrity of the rig could be improved with addition of a mizzen gaff—the present leg-o-mutton mizzen arrangement was only used during the vessel's last four voyages in the codfishing trade.

■ Significant Features

Features that are representative of *C.A. Thayer's* later historic periods are considered significant. Foremost among these is the fisherman's forecastle and the deck house.

Forecastle: A fisherman's forecastle was built into the forward end of the hold as early as 1924. The present forecastle probably dates from 1945, and has been altered to facilitate visitor access by opening up the aft bulkhead. An access ladder from the forecastle to the deck house above was also removed.

Although the forecastle impacts the integrity of the original cargo hold, it is important in interpreting the codfish-

ing period. The remaining cargo hold area is sufficient to give the visitor an impression of this space during the lumber-carrying period.

Deck House: The deck house has undergone numerous modification in overall dimensions and arrangement of the interior. The aft end of the deck house was rebuilt by the U.S. Army following their use of the vessel as a barge during WWII, and inaccuracies were introduced at that time (Dring 1988). At present, it does not accurately reflect any single historic period. During both lumber carrying and codfishing periods, the deck house played a vital roll in the vessel's function and in shipboard life. It should therefore be restored to represent one of these periods, preferably the lumber-carrying period.

■ Nonsignificant Features

Nonsignificant features are mostly limited to the additions and alterations made for visitor access and maintenance. These include gangway, ballast bin, stairs, railings, barriers, and electrical and piping systems. These features alter historic appearance, yet are necessary for maintaining and exhibiting the vessel.

■ Highly Significant Fabric

Fabric that was incorporated into *C.A. Thayer's* original construction, or that was added or replaced during her period of greatest significance (1895-1912) is considered highly significant. In some cases, the origin of fabric will be difficult, if not impossible to determine. Where the

origin of fabric is in question, the fabric is considered highly significant if it is known to predates the museum-ship period and it matches the original construction in detail.

Structure: Foremost among the highly significant structure is visually prominent fabric that shows evidence of usage during the historic period. Such items include:

- Ceiling, with wear and impact marks from cargo loading.
- Hold stanchions, with innumerable nail holes from the fastening of dunnage to secure cargo.
- Waterway timbers and bulwark stanchions, with wear and impact marks from deck loads.
- Main deck planking (forward), with wear from foot traffic into the original crew's forecastle.

Other highly significant hull structure includes the keel, keelsons, deck beams, knees, clamps, pointers, sternpost, some hull frames (excluding those replaced in the bow), aft cabin trunk (excluding planking on top), some interior bulkheads in the aft accommodations, and the quarterdeck bulkhead.

Much of the fabric listed above is in an advanced state of deterioration and will be difficult to preserve in place without considerable effort and use of modern preservation techniques. Of primary concern is the ceiling, which is the most prominent feature of the cargo hold.

Equipment: Highly significant equipment includes the windlass, capstan, steering gear, deck pump, and steam-powered winch. The deck pump dates from ca. 1925 and replaced the original pump that was aft of the main mast. The steering gear, windlass, and capstan are believed to be

original. The winch (atop the deck house) is either original or was installed during a later historic period. These items are largely intact.

■ Significant Fabric

Most fabric not mentioned above can be considered significant if it is in keeping with the vessel's character during any phase of her historic period (1895-1950).

Structure: Significant structure includes fabric replaced during restoration or repairs in the post-historic period: rig, forecastle head deck, hatch coamings, bulwark cap rail, quarter deck rails, samson post, mast partners, port quarter bitts, and much of the hull and deck planking.

Equipment and Furnishings: Several items not original to the vessel were installed during the course of restoration. Many of these items were salvaged from other ships of the period, and can be considered significant artifacts, even if their placement aboard *C.A. Thayer* is not exactly in keeping with her historic character. The appropriateness of these items should be determined through a historic furnishings report. Salvaged equipment includes:

- Wood water tank, donkey engine, steam pump, and mizzen sheet horse from the schooner *Beulah*.
- The ship's wheel from the schooner *Azalea*.
- A steel water tank from *Star of Alaska* (*Balclutha*).

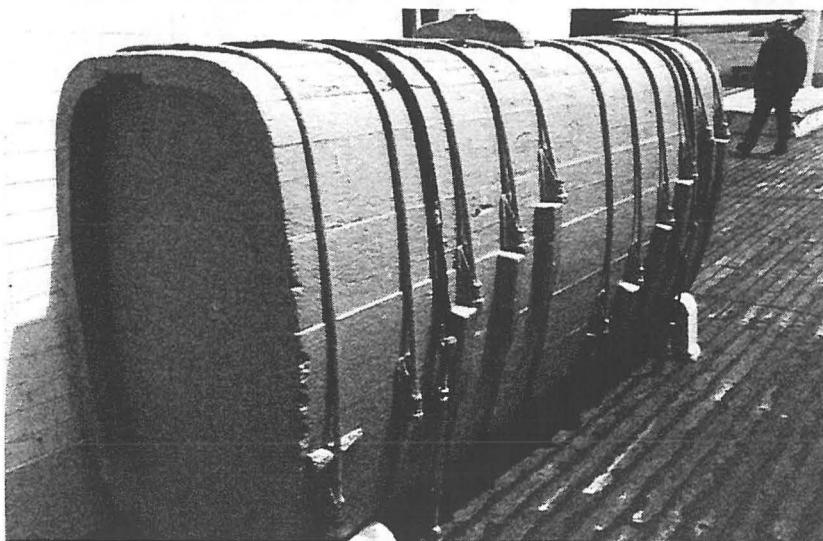
The galley range and saloon stove were also added during restoration. Although their origin is not known, they are authentic and should be treated as significant fabric.

■ Nonsignificant Fabric

Nonsignificant fabric includes items installed for interpre-

Fig. 23. Wood water tank taken from schooner *Beulah*, on port side of deck-house.

Photo: Tri-Coastal Marine



tation and public access (as listed previously), and other items added in the post-historic period. Some of these items are necessary for preservation or exhibit of the vessel. These include:

- Mooring chocks on the port and starboard quarters (installed to facilitate mooring at the Hyde Street Pier).
- Canopy over the fore hatch.
- Wood gratings on main hatch (for ventilation).
- Plywood sheathing on the hull bottom.

Other additions are nonessential and could eventually be removed or reversed:

- The steel bracket along the port waterway and the handrail on the port bulwark (installed for mooring *Alma* alongside).
- Several sister frames in the transom and on the port quarter (these are of hardwood and do not match the original construction).
- Steel knees used in hull repairs at bow and stern.

■ Summary

The most significant features of *C.A. Thayer* are those that

define her as a sailing lumber carrier and a product of West Coast shipbuilding: hull form, rig, general arrangement, and method of construction.

Her most significant fabric is that which is visually prominent and shows evidence of the vessel's use during the historic period: ceiling, hold stanchions, waterways, bulwark stanchions, and some main deck planking.

The major challenge in maintaining the historic integrity of *C.A. Thayer* will be the preservation of the highly significant fabric in her hull. Much of this fabric is believed to be beyond the point that it can be effectively preserved *in situ*. Although modern technology may serve to extend the life of this fabric for a limited time, replacement will eventually be necessary to restore structural integrity. This being the case, efforts to maintain historic integrity would best be directed at preserving significant features, such as the vessel's form, the type and quality of materials in her, and the original method of construction. The level of success this approach will achieve will be in direct proportion to the degree of attention given to details and the effort given to accurate documentation of the existing structure.



■ Measured Scale Drawings

The measured scale drawings in this section are based on measurements taken aboard the vessel between January and May 1989. Structural details that are not based on direct physical survey of the vessel are noted as such. The general hull shape shown in the midship section and profile drawings are based on lines produced by William Doll, SFMNHP, from offsets taken while the vessel was on dry dock in April 1989.

The drawings are a departure from strict existing condition documentation in that they show the hull without existing distortion, primarily hog. This was achieved by returning the keel profile a straight base line, thus removing approximately 14" of hog—a relatively easy process

on paper. The line of the sheer was also altered to remove an equivalent amount of hog, as field measurements indicated that a differential between hog in the keel and sheer was negligible (less than 1"). The result is a representation of the vessel as she is known to have been built. The existing hog has been accurately recorded in keel profile measurements taken in January of 1989 while the vessel was afloat (hog on the keel is graphically illustrated in figure 24, p. 57).

The original drawings are pencil-on-mylar in the following scales:

Outboard Profile and Sail Plan	1/8 inch = 1 foot
Inboard Profile and Plan Views	1/4 inch = 1 foot
Midship Section	1/2 inch = 1 foot
Electrical and Piping	3/16 inch = 1 foot

Scales were selected in order to adhere to the maximum vertical sheet dimension of 22" required by the National Park Service.

The drawings have been reproduced half-size for this report.

■ Analysis of Treatment Alternatives

□ Summary of Treatment to Date

In 1955, the California State Division of Beaches and Parks was authorized by the State Legislature to acquire a sailing lumber schooner. *C.A. Thayer* was purchased in 1956, and restoration began in Puget Sound. Partial repairs were made to her hull in Seattle, where she was also re-rigged and prepared for her last passage under sail along the coast to San Francisco.

The voyage was made in 1957, and further restoration was undertaken upon her arrival in Oakland. In 1963 she was towed to the Hyde Street Pier to become part of the State Maritime Historic Monument. She was fully interpreted, with captions on deck and in her restored accommodations. A “By-Word” audio guide system provided a tour of the vessel, and exhibits in her hold and forecastle told of the lumber trade and Pacific fisheries. She has served in this roll since that time, with only brief interruptions for drydocking and cyclical maintenance.

C.A. Thayer has been successful as a maritime exhibit and her usage has expanded with the development of an Environmental Living Program for grade school students. Were it not for the advanced state of deterioration of her fabric, her most appropriate treatment would be to continue in her present role, with only minor changes to improve historic integrity and expand interpretation. Given her existing condition, however, she cannot continue to perform this role without major intervention. The following is a discussion of the various treatment options, and their advantages and disadvantages.

□ Disposal and De-accession

Due to *C.A. Thayer*’s significance, as confirmed by her National Historic Landmark status, disposal and de-accession are not considered appropriate options. The vessel’s present condition, though serious, does not warrant disposal. De-accession would not ensure the long-term preservation of the vessel unless a capable aegis could be found to accept her. Outside of the National Park Service, there is no known organization with sufficient resources and a record of success in the preservation of cultural resources of this type and scale.

□ Maintain Status Quo

At present, steps to preserve *C.A. Thayer* are limited to routine and cyclical maintenance, with occasional localized repair of deteriorated fabric. While this level of effort would be sufficient to maintain the vessel if she were in good condition, surveys have shown that it has not been adequate to arrest or appreciably slow her rate of deterioration.

Maintaining the status quo would result in the vessel’s eventual decline to a point where, like the steam schooner *Wapama*, she would have to be removed from the water. How long it will take to reach this point is not certain, yet it is unlikely that she could safely remain afloat for more than ten years without major repairs or stabilization measures.

What would be left after this period would be a hull that would very likely be beyond the point of restoration, as key elements such as the keelsons and ceiling would be too weakened by decay to be salvageable as structural members. The only options available at that point would be replication, or dismantling for salvage of fabric for museum display, neither of which are considered appropriate.

□ Stabilization

The stabilization option would attempt to arrest or slow the vessel’s rate of deterioration, but would not undertake major restoration or repairs. Steps would include chemical rot treatment, installation of protective weather covers, ballasting or addition of buoyancy to reduce hogging, and installation of structural members to reinforce the hull and deck.

As an interim treatment, stabilization will probably be necessary in order to achieve long-term preservation. As an end in itself, stabilization has major drawbacks. Although treatment limited to stabilization would have minimal impact on historic fabric, it would seriously alter the historic character of the vessel—a forest of shores in the hold and an encompassing cover over the deck would mar her appearance from within and without.

An additional concern is the fact that stabilization would leave all seriously deteriorated fabric as-is. Much of this fabric is visually prominent and, unlike the visible wear and tear that reflects the vessel’s cultural history, deterioration of this magnitude merely reflects neglect; historically, a vessel such as *C.A. Thayer* would never have been maintained in such a condition.

□ Preservation in a Dry Berth

This option would involve removing *C.A. Thayer* from the water and placing her in a dry berth, either at ground level, in the manner of the steamer *Ticonderoga* in Shelburne, Vermont, or in a pit similar to a graving dock, as was done with the tea clipper *Cutty Sark* in Greenwich, England. Here, she would continue to be interpreted much as she presently is. The rationale for dry-berthing would be to reduce maintenance and preservation costs by removing the vessel from the deleterious effects of the marine environment and the strains imposed on her hull while afloat.

Once dry-berthed, there would be no need for drydocking to accomplish cyclical maintenance. Measures to counteract hogging/sagging strains (such as ballasting, keel girders, or addition of buoyancy chambers) would also be unnecessary. A singular aspect of interpretation could be enhanced in that the underwater hull would be visible and could be interpreted.

The primary drawback to this option lies in the lack of evidence that dry-berthing a wooden-hulled vessel will reduce maintenance costs and ensure preservation. Evidence indicates the contrary; "frequently the maintenance of ships still plagued by deterioration is more difficult than if they were still in the water" (Delgado 1981).

C.A. Thayer could be preserved inside a protective enclosure, as has been done with smaller vessels such as the *Fram* in Norway. A structure at least 125 ft. tall by 230 ft. long by 50 ft. wide would be required to house *C.A. Thayer*. The problem with this approach is the limited availability of sites. It is unlikely that any of the waterfront property in the vicinity of the Maritime Park could be allocated for such a structure. The vessel would therefore have to be separated from the Park and the rest of the fleet, as well as from her historically appropriate waterfront setting.

□ Restoration for Exhibit Afloat

Restoration would primarily involve renewal of deteriorated structural elements as needed to restore hull strength and watertight integrity. This is the only option that will allow *C.A. Thayer* to continue in her role as a floating exhibit without jeopardizing her long-term preservation.

Much of the hull structure has decayed to the degree that replacement will be necessary. Some fabric that is not seriously affected would also have to be replaced as it would inevitably be damaged in the process of disassembling the

hull. Restoration would therefore result in the loss of a major portion of the vessel's historic fabric.

The overriding question concerning this option is whether it is appropriate to sacrifice a significant portion of *C.A. Thayer*'s historic fabric in an effort to keep her afloat and on exhibit. An answer can be found in the relative importance of deteriorated historic fabric in interpreting a ship. While a number of visibly deteriorated maritime artifacts are appropriately displayed and interpreted at the Park's Maritime Museum, a primary role of the historic ships at Hyde Street has been to convey their nature and history to the public through interpretation of each ship's design, construction, and function, as well as the living conditions and routines of those that served in them or rode on them. To this end, intact fabric that retains its historic form serves far better than historic fabric that has lost its original form due to deterioration. The latter can actually be detrimental by giving a false impression of the condition in which such ships were traditionally maintained. The exception to this is historic fabric that has a visible imprint of the vessel's cultural history: the wear and tear of use during the historic period.

Also supporting restoration is the fact that much of the decayed historic fabric in *C.A. Thayer* may be difficult to preserve under any circumstances, even if the vessel were brought ashore and placed inside a protective structure. How much of her significant fabric can be preserved in the restoration process is not certain. Even with further research, an answer may not come until a large portion of the hull has been disassembled, a point at which there would be no turning back. For this reason, pursuit of this option will require acceptance of the possibility that the end product of restoration may contain only a small percentage of significant historic fabric.

A benefit of restoration shared by no other treatment option is the possibility of sailing *C.A. Thayer*. Once hull strength and watertight integrity are restored, relatively little additional work would be required to outfit the vessel for sailing on San Francisco Bay. If undertaken only occasionally, sailing should not pose a significant threat to the safety of the vessel and would benefit her preservation by generating public interest that would result in improved maintenance (an example of this can be seen in the volunteer sailing program of the scow schooner *Alma*).

Restoration could be accomplished under a variety of different programs. The range of options are as follows.

■ Restoration Through Periodic Repairs

Restoration could be achieved by systematically renewing a limited portion of the structure at each maintenance cycle. This approach would result in numerous steps being phased over a considerable length of time, though the work would have to be accomplished at a rate faster than that of advancing deterioration.

The advantages to this method of restoration are that it would not necessitate removing the vessel from public display for an extended period of time and would not require a major amount of funding in any single fiscal year.

There are several disadvantages, not the least of which is cost—with a start-stop program, the overall project cost can be expected to at least double. Wastage of material and labor would also result, as structure that has been renewed during one phase would have to be partially disassembled to carry out repairs in subsequent phases. The original method of construction, a significant feature of the vessel, would be altered, because the piecemeal approach to restoration will not allow use of long lengths of timber or traditional methods of assembly. The end product would therefore be inferior to the original construction in terms of hull strength and historic integrity.

■ Restoration in Two to Four Phases

By carrying out the restoration in a limited number of phases, the overall project cost can be reduced from that of the piecemeal approach. Each phase would address a major portion of the vessel, thus allowing restoration work to more closely approximate the original method of construction. Following each phase, the vessel would be reassembled and refloated, and could thus be returned to her berth for display between phases.

There are numerous possible variations of the phased approach to restoration. One approach would be to renew the upper works of the hull (deck structure, waterways, upper ceiling and top timbers of frames, clamps, and topside planking) in one phase, and the bottom structure (keelsons, lower ceiling, and floor timbers) in a second

phase. Alternately, restoration could be carried out in a longitudinal fashion, beginning at the bow and working to midships in one phase, and from midships to the stern in a second phase. Both of these methods could be broken down into four phases by alternately working the port and starboard sides.

Regardless of the sequencing, material and labor would be wasted in an effort to structurally tie in each phase of the work. Overall cost and amount of wastage would increase in proportion with the number of phases.

■ Restoration in One Phase

Restoration of the hull in one uninterrupted phase is the most economical approach and would result in the best end product. Overall project costs would be considerably reduced. Extensive disassembly of the hull will be possible, thus allowing the structure to be rebuilt in much the same manner as it was originally constructed.

The major drawback to a single-phase restoration is the demand it will place on the Park's resources, as adequate funding will have to be available to complete the work without interruption. This approach will also remove the vessel from public display for an extended period of time, possibly as long as eighteen months.

□ Conclusions

C.A. Thayer should be preserved in a manner that will allow her to continue in her successful role as a floating museum ship. Restoration is the only treatment that will support this use over the long term and is therefore the recommended treatment.

Restoration would best be achieved in a single-phase program. Developing and carrying out such a program will require considerable lead time for planning, further research, and acquisition of materials, skilled labor, and a suitable site.

For this reason, stabilization is recommended as an interim treatment to prevent further loss of historic fabric and weakening of the hull due to ongoing decay. A recommended program for treatment is discussed in the following section.



■ Proposed Treatment

□ Overview

The proposed treatment for *C.A. Thayer* is restoration for continued use as a floating exhibit. Long-term preservation of the vessel in a marine environment can only be achieved by restoring the hull and deck structures to a maintainable condition. An interim phase of stabilization will be necessary to arrest or slow further deterioration and distortion of the hull until restoration can begin.

The proposed treatment represents a large and complex project that will require considerable preparation and planning to successfully undertake. Additional study must be completed before a detailed scope of work and restoration plan can be developed. Important questions that remain to be answered include:

- The precise condition of hidden structure, principally the floor timbers, frames, keelsons, and the outboard face of ceiling planks. The Existing Condition Survey has provided only a general assessment of the condition of these members.
- The degree to which dry rot is continuing to degrade the hull structure.
- The original method of assembly, primarily the lengths and arrangement of frame futtocks, and the quantity and distribution of fastenings in the backbone members and ceiling.
- The technology available for consolidating and preserving severely decayed wood, and its applicability for use in *C.A. Thayer*. This will have a major bearing on the amount of decayed structure that can be saved.
- The availability of materials, particularly Douglas fir of the size and quality required to duplicate *C.A. Thayer*'s original construction.
- The availability of a suitable restoration site.

While the precise treatment for certain elements of the vessel will depend on the answers to some of the above questions, the principle steps of the proposed treatment have been identified and are enumerated in this section, along with a discussion of the major considerations for each. The recommended scheduling of the treatment is covered in the section "Cost Estimates and Implementation Schedule." The following is a basic outline of the required steps arranged in a two-phase program. Phase I would involve initial planning and study, and necessary stabilization measures; restoration would take place in Phase II.

■ Phase I

□ Preliminary Work:

- Analysis of hull loading
- Survey and investigation of hull structure
- Analysis of decay
- Acquisition of lumber
- Design and engineering for stabilization measures

□ Stabilization:

- Upgrade of electrical system
- Chemical rot treatment
- Seasonal weather covers
- Structural reinforcement/ballasting

■ Phase II

□ Restoration:

- Planning
- Site acquisition and development
- Acquisition of remaining materials
- Contract development and award
- Remove salvageable elements (rig, deck house, forecastle, aft accommodations)
- Drydocking
- Restoration of hull
- Re-floating
- Reinstatement of salvageable elements
- Installation of new systems (electrical, piping, public access facilities, interpretation)

□ Phase IA: Preliminary Work

Initial efforts should focus on the prerequisites for beginning the stabilization phase, and on the tasks necessary to begin development of a comprehensive plan for restoration. Acquisition of materials, particularly those with the longest lead time for delivery, should also begin in the preliminary phase. Preliminary work should be completed as soon as possible.

■ Hull Loading Analysis

A hull loading study will be needed to determine the amount of force that is acting to distort *C.A. Thayer*'s hull. The study will involve development of a "loading curve," a graphic representation of the ratio between weight and buoyancy in the hull. Development of the loading curve will require the hull lines or offsets to determine buoyancy, and a "weight survey" to locate and quantify all major weights aboard the vessel.

The loading study should be completed as soon as possible, as the results will determine whether stabilization

measures will be needed in the form of ballasting, additional buoyancy, or structural reinforcement. The study would be performed by a marine engineer or naval architect, and would be followed by recommendations and design work for corrective measures.

Estimated Cost \$ 15,000

■ Analysis of Decay

There is visible evidence of the effects of decay, but the amount and location of active decay that is still doing damage to the structure remains an unknown. The presence of active decay can be determined by taking core samples for laboratory analysis. To get a representative sample, 40-60 cores should be taken in suspect areas of the hull structure. Moisture readings should also be taken at numerous locations in the upper portion of the hull. If significant viable decay is found, remedial treatment will be necessary to arrest or slow its progress. High moisture readings (over 25 percent moisture content) will indicate the need to provide weather protection to stop rainwater intrusion.

Estimated Cost \$ 2,000

■ Additional Structural Survey

Before a comprehensive restoration plan can be developed, additional surveying will be needed to more accurately determine the condition and method of construction of the hull, particularly certain key elements that are presently concealed. To accomplish this, selected ceiling and hull planks would be removed to gain access to the internal hull structure. This work would be performed while the vessel is on dry dock for cyclical maintenance.

It is recommended that the ceiling planks adjacent to the sister keelsons be removed to permit visual inspection, coring, and sounding of the top of the keel, bottom of the keelsons, floor timbers, and naval timbers. Removal of a full strake of hull planking at or just below the turn-of-bilge would allow inspection of the lower frame futtocks and the outboard surface of the bilge ceiling. The condition of these members will be a major factor in determining the scope of work and method of approach to the restoration. Removal of planking will also allow documentation of the arrangement of frame futtocks, information that is needed to order the proper sizes of lumber for milling replacement futtocks.

Another important question to be answered is whether the ceiling is edge-fastened. Edge-fastening is suspected, but has not been confirmed. The location and arrangement any edge-fastenings should be documented on a ceiling expansion drawing.

Since edge-fastenings would be of iron, they could probably be located using a magnetic probe.

The survey data and information gathered through additional survey should be compiled and recorded on structural drawings. These would then serve as the base-line data for restoration planning.

Estimated Cost
Survey \$ 6,000
Structural Removals \$ 60,000
Total \$ 66,000

■ Acquisition of Lumber

Acquiring the lumber for restoration of *C.A. Thayer* will be a major task requiring considerable lead time. An estimated 350-400,000 board feet of lumber will have to be ordered to ensure that enough material is on hand to rebuild *C.A. Thayer*'s hull. Timbers of the dimensions needed, particularly the long lengths, are not commonly available from today's lumber mills. Dense Douglas fir comparable to the original fabric (and the most desirable from the standpoint of strength and resistance to decay) will also be difficult to find in the sizes and quantities needed.

The first step will be the development of a detailed lumber list with specifications. The list should include the following information for each type of stock:

- Rough dimensions
- Finish dimensions and milling specifications
- Total linear footage
- Lengths (allowing for a proper shift of butts with minimal wastage)
- Grade (per West Coast Lumber Grade Rules and any additional requirements)

Another important factor will be the moisture content of the wood. Wood that is "green" (with a high moisture content) when installed will shrink as it dries, thus checking, opening up joints, and reducing the holding power of fastenings. This is particularly a concern in the upper portions of the hull where shrinkage will reduce watertight integrity and thus promote decay.

Lumber for the deck planking, topside planking, waterways, top timbers, and deck structures should have a moisture content of no more than 18%.

Lumber for the lower hull framing, ceiling, clamps, keelsons, and bottom planking can have a moisture content of about 25%.

Most of the lumber will have to be ordered green and carefully stored for air-drying, as it will probably not be

possible to purchase quantities of air-dried lumber. For the larger timbers, drying time will be as much seven to ten years. For this reason, the larger timbers (those for keelsons, deck beams, and top timbers) should be ordered first.

In addition to the above requirements, pre-treatment of the lumber with wood preservative could be specified. The best means of getting preservatives into the wood is through pressure treating, a process that should be performed before the lumber is delivered. For reasons of safety, only nontoxic chemicals should be used.

A market survey will be needed to locate sources for the lumber. In addition to the major mills, other sources should be investigated, including small mills and those specializing in custom orders. The National Forestry Service should also be consulted; a cooperative agreement may allow access to select timber on National Forest lands. It is recommended that an arrangement be made with a qualified purchasing agent to locate and inspect the lumber, and arrange for its purchase. Such a person should be a licensed lumber inspector or someone familiar with the rules for grading Douglas fir.

Enough lumber should be ordered to replace all structural members—there is no guarantee that any of the existing hull structure can be saved and a shortage of lumber during the restoration process will result in costly delays. To ensure a sufficient supply of lumber, an additional amount of material should be ordered to allow for wastage (board footage lost in cutting timbers to length and due to rot and warping while in storage).

As much as 400,000 board feet of new lumber may be required to restore *C.A. Thayer*. With an estimated average cost per board foot of \$3 to \$4 F.O.B., the total cost for lumber would range from \$1.2 to \$1.6 million (costs associated with storage and final milling will be additional).

An initial lumber purchase that includes the timbers with the longest drying time would be about 20% of this total, or \$240-320,000. The work of acquiring this much lumber can be expected to keep a purchasing agent busy for many weeks, if not months. On-site inspection of the lumber is recommended before purchase and shipping.

□ Phase IB: Stabilization

The stabilization phase will involve a series of steps to protect the vessel, arrest decay, and prevent further hogging. Some of the steps to be taken will be determined in part by the results of the survey and analysis completed in the preliminary phase. Steps that are not contingent on further study should be taken immediately.

Stabilization will have to be sufficiently effective to prevent significant loss of structural integrity during the extended interval before the restoration phase begins. This interval may last for several years due to the time required for air-drying the lumber. If successful, stabilization could allow a further deferral of the restoration phase, though it cannot be considered a solution for *C.A. Thayer*'s long-term preservation.

■ Upgrade of Electrical System

C.A. Thayer's electrical system is presently a safety liability as a potential source of fire. An accidental fire is the quickest way to lose the vessel, and poses a threat to those staying aboard overnight in the Environmental Living Program. Due to the number of deficiencies in the existing system, much of the wiring, conduit, and fixtures will need to be replaced in order to reduce the fire risk. This work is considered a high priority and should be completed in the stabilization phase, even though it would be more economical to wait until the restoration, when the entire system will have to be removed in any case.

The initial upgrade of the electrical system can be kept simple, replacing existing circuits as needed to bring the system up to a minimum acceptable standard (National Electrical Code). Following restoration, a redesigned system should be installed that will meet the present and future needs of public access, interpretation, and maintenance.

■ Arresting Dry Rot Decay

There is little doubt that dry rot decay is continuing to do damage to *C.A. Thayer*; the question is how much and where? The analysis recommended as preliminary work should quantify and locate areas of active decay. While many portions of the hull are already too decayed to be preserved (further decay in these areas will have little impact), certain key elements of the hull may be in a borderline condition. Ongoing decay in the ensuing period before restoration begins could render them beyond preservation, thus increasing the cost of restoration and furthering the loss of historic fabric.

Three measures can be taken to reduce or arrest decay: chemical treatment, use of weather protection during the wet season, and increased ventilation. The decision to implement them should be based on the results of analysis. A description of these measures is given below.

□ Chemical Treatment

The best option for chemical treatment appears to be sodium borate (TIMBOR), a nontoxic product that has

been used experimentally to treat decay in the steam schooner *Wapama*. Extensive use of this product on *C.A. Thayer* will be complicated by the fact that she is afloat and open to the public. The primary difficulty will be compliance with regulatory agencies which will likely object to the proliferation of sodium borate into the Bay.

Spray application of the chemical above deck would result in excess runoff going overboard. If applied in the hold, sodium borate would eventually drain into the bilges where it would be pumped overboard with the bilge water. Unfortunately, sodium borate cannot be easily filtered out of the bilge water. A possible option would be to connect the bilge system outflow to the City sewage system (sodium borate commonly enters the sewage system as a component of Borax-based laundry detergents).

To solve this and other compliance problems, a system of application should be developed in consultation with local regulatory agencies. The following procedure is recommended starting point for seeking approval for use of sodium borate.

1. Drill drain holes in the main deck and attach hoses to direct runoff into the bilges rather than through the scuppers.
2. Install an auxiliary connection (with valve) from bilge pump discharge to sewage line on pier.
3. Apply sodium borate as follows:

Decks: wet deck and apply a thick paste to deck seams over the deck beams, along waterways, and around the base of deck structures. Rinse off after several hours.

Hold: using garden sprayer, apply an aqueous solution to ceiling.

Keelsons: place sodium borate blocks on top of rider keelson in areas where moisture is seen.

Frames: place fabric bags of sodium borate powder in spaces between frames in general location of existing salt shelves.

The use of fumigants, such as Vapam, should be considered for treating the larger timber, particularly the keelsons, which cannot be effectively treated with sodium borate. Before preservatives are applied on a major scale, a well-structured plan should be developed to control application, assure compliance with regulatory bodies, and monitor the results.

□ Weather Protection

Arresting widespread decay in the hull structure will be difficult without stopping rain water leakage through the deteriorated weather decks and topsides. At present, the planking and caulking are too rotten to provide an effective weather seal. Until the decks and topsides can be rebuilt, awnings or covers over the vessel appear to be the only means of keeping fresh water out of the structure.

To be effective, weather protection will have to extend over all weather decks, and should overhang the sides of the vessel to prevent runoff from soaking the topsides. The most practical approach would be to erect a fabric cover supported by a rigid framework. Side curtains, to protect the topsides from wind-driven rain, would provide further protection. Weather covers should be designed for seasonal removal, as they will only be necessary for approximately six months out of the year.

Weather covers are not without drawbacks; they will significantly impact the appearance of the vessel and will require a considerable amount of labor for installation, removal, and maintenance. Although weather covers are recommended as an initial stabilization measure, the decision to install them in future seasons should be based on the success of chemical rot treatment. If the hull can be thoroughly saturated with preservatives, the periodic presence of fresh water might be mitigated.

□ Ventilation

In terms of interior spaces, *C.A. Thayer* is generally open and has reasonable natural-draft ventilation. The one exception is the area beneath the sole of the fisherman's forecastle. This area remains moist enough to promote decay, despite the installation of vented hatches in the sole a few years ago. Moisture in this area can be reduced to an acceptable level by cutting away the aft forecastle bulkhead below the level of the forecastle sole (a screened barrier would have to be placed across the opening to keep visitors out). Installation of a high-volume, low-velocity fan beneath the sole would provide additional positive air flow, but should be used with discretion, as too much air flow could result in excessive drying of the hull structure in the area.

The moisture level in the frame spaces, between ceiling and outer planking, could be reduced if the lower ceiling planks are removed from port and starboard sides, as recommended, for additional survey. This step would allow the passage of air between the centerline and the air-strake beneath the clamp, thus providing ventilation to most of the ceiling and frames in the midbody.

■ Reducing Hull Loading

With an empty hold, *C.A. Thayer* has too much buoyancy amidships, a condition that places a structural load on the hull and promotes hogging (an upward arching of the keel). Although hull loading has remained relatively constant over the past forty years, the hull has weakened and succumbed to this force, thus leading to further hogging. Blocking plans from previous drydockings show the hog in *C.A. Thayer*'s hull to have increased progressively (see figure 24). Hogging results in hull distortion that is unsightly and difficult to reverse (there are accounts of hog being removed from large wooden vessels, but only by disassembling most of the hull to let the keel settle back to a straight baseline over time).

Due to the fact that restoration will tend to permanently lock in hull distortion, stabilization measures are recommended to prevent further hogging and preserve the vessel's hull form until restoration can begin.

The results of the hull loading study (recommended as preliminary work) should determine the degree of hogging strain and indicate the appropriate steps to be taken. There are several possible methods of neutralizing hogging strain, each with its advantages and disadvantages.

□ Ballasting

Ballasting is the most conventional method. It would involve placing heavy material, such as steel, lead, concrete, or even water ballast, in the hold to counter excess buoy-

ancy. A problem with ballasting is that it adds to the overall weight of the vessel, thereby increasing mooring strains that in themselves contribute to hull distortion. Unless the ballast is very dense, it will take up valuable space in the hold, thus limiting visitor access and obscuring the artifact they are there to see.

Using lead ingots, it would be possible to conceal up to 70 long tons of ballast (156,800 lbs.) beneath the existing bilge boards in the hold. If this were done, there would be no impact to visitor access. The ability of the hull bottom to support this concentrated weight should be determined before committing to this method. A key factor will be the condition of the floor timbers, which should be determined by the additional inspection recommended as preliminary work.

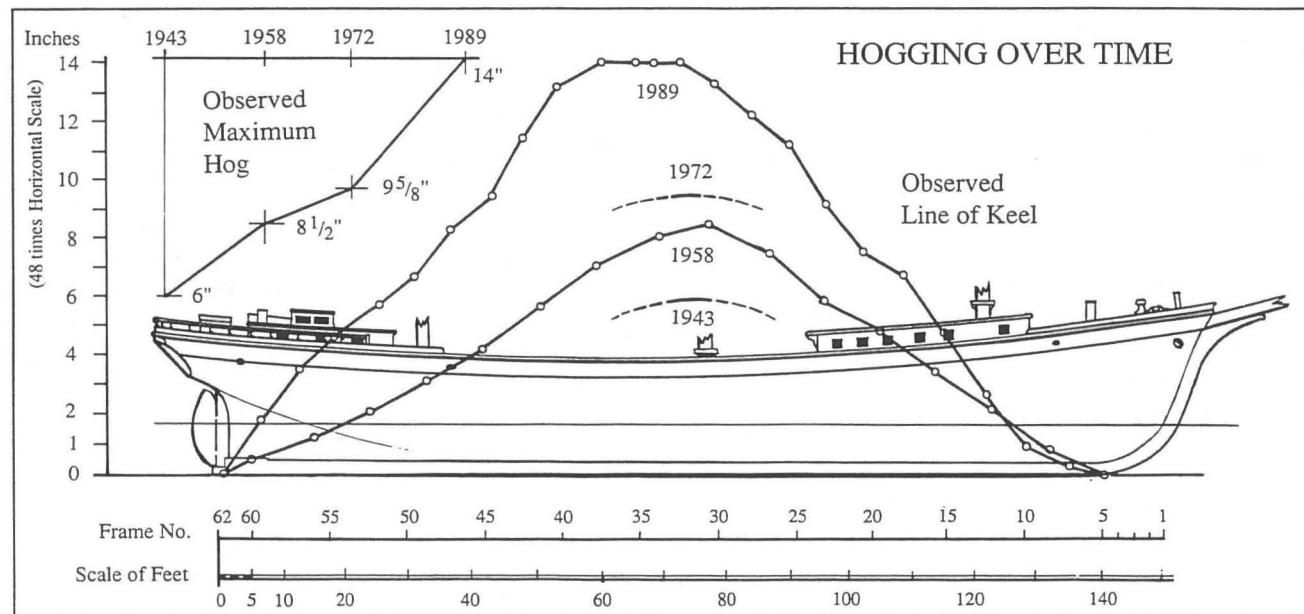
□ Buoyancy Chambers

Buoyancy chambers, flotation tanks fitted to the underwater hull to support the fore and aft ends, have not been widely used, but are theoretically the best way to neutralize hogging strains. They do not add weight to the vessel and would have no visual impact. The drawback is that the chambers would have to be removed in order to move the vessel to dry dock for cyclical maintenance. Arrangements can be worked out for flooding the chambers and sinking them out from under the hull when the vessel is to be moved.

There is a practical limit to how much hogging strain can be reduced using buoyancy chambers. If the results of the

Fig. 24. Graphic presentation of hogging.

Graphic: D. Canright, Tri-Coastal Marine



hull loading study show a sizable deficiency of buoyancy at the ends, buoyancy chambers may only be useful in conjunction with other measures, such as ballasting.

■ Keel Girder

Another method of preventing hogging is to strengthen the backbone of the hull by attaching a girder to the bottom of the keel, thereby giving the hull sufficient rigidity to resist hogging strain. A keel girder would be a member as wide as the existing keel and as much as 4 feet deep, and could be constructed of steel or reinforced concrete. The keel girder would have no visual impact when the vessel is afloat, and would not add significant weight.

A keel girder may also have application as a permanent preservation measure by allowing a weakened backbone (keel and keelsons) to be retained rather than replaced. As with buoyancy chambers, this method has practical limits. In the case that hogging strain is high, the connection between the wood keel and the hull will come under increased stress. If the floor timbers and fastenings are in poor condition, they may not have sufficient strength to keep the hull secured to the stiffened keel.

Ultimately, a combination of the measures outlined above may provide the best solution to the hogging problem. The choice of methods should be based on the results of further survey and on sound naval architecture.

■ Routine and Cyclical Maintenance

C.A. Thayer requires a high level of routine and cyclical maintenance due to her deteriorated condition, and this level can be expected to increase until she is restored. The vessel cannot be effectively stabilized unless the present maintenance effort is expanded. Recommended steps are as follows.

- Wash down weather decks with sea water on a daily basis. This measure will help to prevent further decay of structures below the leaking decks (deck beams, ceiling, knees). If areas of the decks are treated with preservatives, routine washdown may not be necessary. Likewise if weather covers are installed. Following each washdown, rinse all metal deck equipment with fresh water to remove corrosive salts.
- Pay leaking deck seams with marine glue.
- Reef out and pay the cabin trunk (do not use window glazing—this product has not performed well in the past).
- Hose down and pay forecastle head deck.
- Scale and coat all corroding metal surfaces with anti-corrosive paint or soft-film coatings.
- Annually end-for-end the vessel in her berth.

■ Drydocking for Cyclical Maintenance

At the next drydocking, the bottom should be carefully inspected for signs of marine borer damage, particularly in the areas of exposed hull planking. Some of the bottom planking is so rough, with splintered wood and old fastenings holes, that marine borers may find avenues into the wood despite the presence of antifouling paint. The waterline area is of particular concern due to the decay seen in the waterline planking when sheathing was removed during the last drydocking.

The remaining plywood bottom sheathing should be left in place, except in cases where there is evidence that marine borers have penetrated the sheathing. The sheathing will continue to provide protection against marine borers until restoration begins, after which it would no longer be necessary if a regular drydocking schedule is strictly adhered to.

Replacement of bottom planking will be difficult due to the deteriorated framing. Removal of stakes of bottom planking for survey of the inner hull structure should begin with one plank, and halted if floor timbers are found to be too deteriorated to fasten new planking to.

C.A. Thayer should be drydocked at least every two years. Given the present condition of framing and hull planking, it is not unlikely that emergency drydocking will be necessary as hull leaks develop. Preparation should be made for shifting the vessel to dry dock on short notice. (A lesson was learned in the fall of 1988, when hull leakage increased dramatically due to worm damage—it took six months to get the vessel on dry dock for repairs!)

Once *C.A. Thayer* has been restored, she should continue to be drydocked at two-year intervals. Annual drydocking will not be necessary if effective antifouling bottom paints are used, and if she does not rest on the bottom of the slip at low tide (grounding will tend to remove the protective bottom paints). To drydock her every year would pose an unnecessary risk; each time a large wooden vessel is drydocked, there is a possibility of strain resulting in damage.

■ Conclusion of the Stabilization Phase

The stabilization phase may last for several years as the necessary preparations are made for restoration. Determining the success of stabilization measures will require routine monitoring of the process. The following steps are recommended for tracking the results of treatment.

Routinely:

- Monitor the rate of leakage of the hull.

Every Six Months:

- Take core samples and analyze for decay.

- Take cores for chemical analysis (if sodium borate treatment is used).

Every Year:

- Use gauge wire or surveyor's level in hold to monitor hull alignment. Check for further hogging, racking, or twisting of hull.

Every Two Years:

- Measure keel profile.
- Survey the entire hull for signs of advancing deterioration and distortion. Compare to previous data to determine rate of deterioration.

□ Phase II: Restoration

The primary objective of Phase II is to restore strength and watertight integrity to *C.A. Thayer*'s hull and deck. Historic integrity would be maintained through in-kind replacement of unsound fabric. Where possible, historically significant fabric would be preserved through the use of modern preservation techniques.

A recommended general approach to restoration is outlined in this section. Further research and planning will have to be completed before the restoration process can be defined in detail.

■ General Approach

Restoration of the hull would be completed in one uninterrupted phase. This approach will be the most cost-effective and will allow a closer adherence to the original method of construction.

Hull work would be performed with the vessel out of the water. To avoid excessive drying of existing fabric, the out-of-water portion of the work should be completed and the vessel re-floated within eighteen months.

Components such as deckhouse, forecastle, aft accommodations, and rig would be removed for restoration or preservation, and reinstated following completion of hull work.

The deck house and cargo hatches would be restored to their arrangement during *C.A. Thayer*'s period as a lumber carrier. The present arrangement (largely the result of modifications made by the U.S. Army during World War II) is not in keeping with that of a lumber schooner and does not benefit interpretation of later periods.

The fisherman's forecastle would be reinstated as-is; this feature is significant, and is essential to the interpretation of *C.A. Thayer*'s codfishing period.

The existing electrical and piping systems would be scrapped, and replaced with systems that meet current safety standards.

Before restoration of the hull begins, materials sufficient to replace all major structural elements should be in hand. Lumber should be procured well in advance to allow air-drying to an appropriate moisture content.

■ Planning

The restoration of *C.A. Thayer* should be approached with the same level of research and planning with which the National Park Service undertakes technically challenging preservation projects, such as the Statue of Liberty restoration.

The basic input for planning would include the work of the Historic Structure Report and previous studies, and the results of survey and analysis in Phase I. The output of planning should include:

- Detailed structural drawings of major hull assemblies.
- A list of materials, with specifications, sources, and cost estimates.
- A detailed restoration sequence.
- Procedures, specifications, and labor requirements for work to be performed in-house.
- Contract documents and cost estimates for work to be performed under contract.
- Identification of a suitable work site and start-up requirements.

Planning work may stretch over an extended period, but should begin in Phase I. A conservative estimate of the research and planning component for a project of this magnitude and complexity would be 3% of the total project cost, or \$150-200,000 of the estimated \$5-7 million total restoration cost.

■ Hull Restoration

Restoration of *C.A. Thayer* will involve renewal of a large percentage of the structural fabric of the hull. The amount of hull fabric to be renewed (and conversely, the amount that can be preserved) cannot be determined with certainty until the hull is disassembled. Even with a detailed assessment of the condition of all structural members, it will not be known which members will survive the disassembly process in adequate condition to be salvaged or preserved. For this reason, restoration should only be undertaken if there is acceptance of the possibility that only a small percentage of the existing fabric would be retained. Furthermore, the work should not begin until all materials and resources are at hand to replace all hull fabric.

The estimated percentages of major structural elements to be renewed, based on the survey of existing condition, are given below. The percentages assume that an effort to preserve some of the ceiling, deck beams, and knees will be successful.

Hull Planking:	renew 95% (possibly salvage garboard)
Framing:	renew 80%, retain remainder
Ceiling:	renew 25%, preserve 75%
Clamps:	renew 100%
Deck Beams:	renew 50%, preserve 50%
Deck Planking:	renew 80%, retain 20% (under aft accommodations)
Deck Stringer:	renew 100%
Hanging Knees:	renew 25%, preserve 75%
Lodging Knees:	renew 50%, preserve 50%

The keel is thought to be salvageable, but the percentage of renewal required for the keelsons and floor timbers cannot be determined without further disassembly and survey of the hull structure.

The recommended treatment and general considerations for each of the major structural elements of the hull and decks are as follows.

☒ Hull Planking

Almost all of the hull planking would have to be removed for restoration of the hull. Most of the planks are too rotten to be saved and others will be damaged in the removal process. Some planks might be removed intact by drilling out the trunnels fastening them to frames, or by cutting around iron spike fastenings with a hole saw. This process would be time-consuming, but might be worthwhile in the case of the garboard strake or other strakes that have long planks that are in good condition.

Replacement planking should duplicate the original planking in width and thickness. Where the original lengths and shift of butts can be determined, these features should also be duplicated. In lieu of any evidence of original plank lengths, the longest possible lengths should be used. Trunnel fastenings will generally indicate original hull planking; ship spikes were only used in later repairs. A "shell expansion," or map of the hull planking, should be produced to document both existing and replacement planking.

☒ Frames

There are sixty-two frames between the forward perpendicular and the sternpost, approximately forty-three of which are "full frames," frames with floor timbers that pass between the keel and keelsons (see Measured Scale Drawings, Sheets 4 and 5). Survey data indicates that almost all frames are rotten from the top timbers down to the turn-of-bilge. The condition of the floor timbers and naval timbers is not known. If floor timbers are too deteriorated to fasten new frames to, they will also have to be renewed. Renewal of floor timbers will require separation of the keel from the keelsons, a process that will substantially increase the scope of work for hull restoration. As recommended in Phase I, an effort should be made to determine the condition of floor timbers at the next cyclical drydocking. The lengths and arrangement of the individual futtocks, and the size and type of fastenings holding them together to form the frames, are also unknowns that should be documented prior to beginning restoration.

The recommended method of renewal is to remove deteriorated futtocks from the outside after the planking has been removed. Separating the futtocks from the ceiling will be a labor-intensive task due to the number of fastenings securing frames to ceiling (four clench-bolts and four trunnels in each ceiling plank at each frame!). Replacement futtocks would be templated from existing futtocks or from the outer face of the ceiling, then pre-assembled to form half-frames, and fastened to the existing floor timbers. If renewal of floor timbers is necessary, several steps would be added to the process, though frames would still be pre-assembled and installed as described.

The existing frames will have to be handled with caution due to the presence of a toxic grease-based preservative (2-5% pentachlorophenol) on the surface of the upper futtocks. The preservative was probably applied by the U.S. Army when they rebuilt the midbody in the 1940s, and may be present on other surfaces, including the inboard face of hull planking and the outboard face of ceiling.

☒ Ceiling

Treatment of the ceiling will be perhaps the most problematic of the hull restoration. The ceiling gives longitudinal strength to the hull. It is also historically significant and visually prominent fabric. While the inboard face of the ceiling appears relatively intact, sample borings indicate that the outboard face of most planks is severely decayed. Based on the observed degree of deterioration, it is unlikely that the ceiling retains more than 50% of its original strength. Furthermore, the outboard face of the ceiling is too deteriorated to fasten new frames to.

In-kind renewal would be the simplest solution, and may ultimately be necessary, but would result in the loss of the characteristic patina on the unpainted surface of the ceiling planks. This patina, the result of years of wear and tear from cargo loading, is indicative of *C.A. Thayer's* working history and is considered significant. Unfortunately, there appears to be no effective means of preserving the ceiling *in situ*.

An option for preserving the ceiling by removing each plank and subjecting it to a preservation treatment is illustrated in concept in Figure 25, p. 62. This treatment would restore sufficient strength to the ceiling, while retaining the appearance, but would be labor intensive as it would involve several steps in addition to removal and installation. Furthermore, it may be difficult to remove ceiling planks without irreparably damaging them, particularly if they are found to be extensively edge-fastened. If some of the planks cannot be preserved, the effect would be a patchwork of old and new planking, a result that would not be worth the effort. The workability of this option cannot be determined until an attempt is made to remove ceiling planks intact.

The ceiling forward of the forecastle bulkhead (approximately 30% of the total) can be renewed without visual impact; the ceiling in the fisherman's forecastle is painted and that below the forecastle sole is out of view. Much of the ceiling in the forepeak has previously been renewed using very short lengths. These planks should be replaced with longer lengths that tie in structurally with the forecastle ceiling.

□ Clamps

The clamps, like the ceiling, are decayed on the outboard surface along much of their length. In addition, they have stress cracks in way of the forecastle. The clamps are the most substantial longitudinal members of the upper hull and renewal is recommended in the interest of restoring hull strength.

Unlike the ceiling, the visual impact of renewing the clamps will be minimal; they do not show significant signs of age or usage. In-kind renewal will require two 80' lengths of 12" x 14" timber. If good quality timber cannot be found in this length, scarfing would be the next best option. The scarfs can be located behind the hanging knees, where they will not be visible.

□ Centerline Timbers

The centerline timbers consist of the keelson, rider keelson, four assistant keelsons, and the keel (see Measured Scale Drawings, Sheet 5). These timbers form the "backbone" of the hull, giving strength and rigidity to the bot-

tom half of the hull girder. Test borings taken during survey show internal decay at various points along the assistant and rider keelsons.

The condition of the keelson itself is not known, but is suspected of being in similar condition. The lower portion of the keel appears to be in good condition; the portion above the rabbet line is not visible and condition is not known. A more precise assessment of the condition of centerline timbers should be obtained during the next cyclical drydocking by removing bottom planks near the garboard stake to allow visual inspection and test borings.

The treatment for the backbone will depend on the severity of decay. The three most likely scenarios are:

- If the floor timbers are found to be in poor condition, they will need to be renewed, thus necessitating removal of the keelsons. In this case, it would be most appropriate to renew all or most of the keelsons, as they will likely be damaged by removal.
- If most of the floor timbers are in fair to good condition, the lower keelsons might be retained, and the upper keelsons renewed to restore adequate hull strength. This would include renewal of the rider keelson and the two upper assistant keelsons. All timbers that are retained would be thoroughly treated to prevent further decay.
- The third scenario would also depend on the floor timbers being in acceptable condition. It would involve attaching a rigid girder or beam along the bottom edge of the keel, as described in "Reducing Hull Loading," p. 57. The girder would stiffen the backbone and mitigate the loss of strength due to decay in the keelsons. This method could allow all or most of the keelsons to be retained, though they would need to be thoroughly treated to prevent further decay.

In any case, the recommended treatment is that which allows retention of as much existing fabric as possible, while restoring sufficient strength to resist bending strains.

The condition of the stem, sternpost, and fore and aft deadwood is not known, but renewal of some of these members should be anticipated. The bow was rebuilt in 1969, and although the timbers replaced at that time are probably still sound (pentachlorophenol preservative was used), the work is inferior, both structurally and in terms of historic integrity, due to the use of short timbers for planking, ceiling and deadwood. Replacement of these timbers is recommended. The stern post has an area of marine borer damage, but may be sufficiently sound to preserve.

□ Hold Stanchions

There are twenty-one hold stanchions, eighteen of which are thought to be original due to the pattern of nail holes on their surface, the result of dunnage being nailed to secure cargoes over many years of service. Most of the stanchions are in fair condition and should be preserved. They can be removed and reinstated with relative ease. New stanchions will have to be installed to replace those removed by the U.S. Army when the hatches were enlarged (one at the aft end of the main hatch, and two at the forward end of the fore hatch). Two stanchions were also removed from the forward end of the hold when the fisherman's forecastle was installed. These should be removed in order to maintain the historic arrangement of the forecastle.

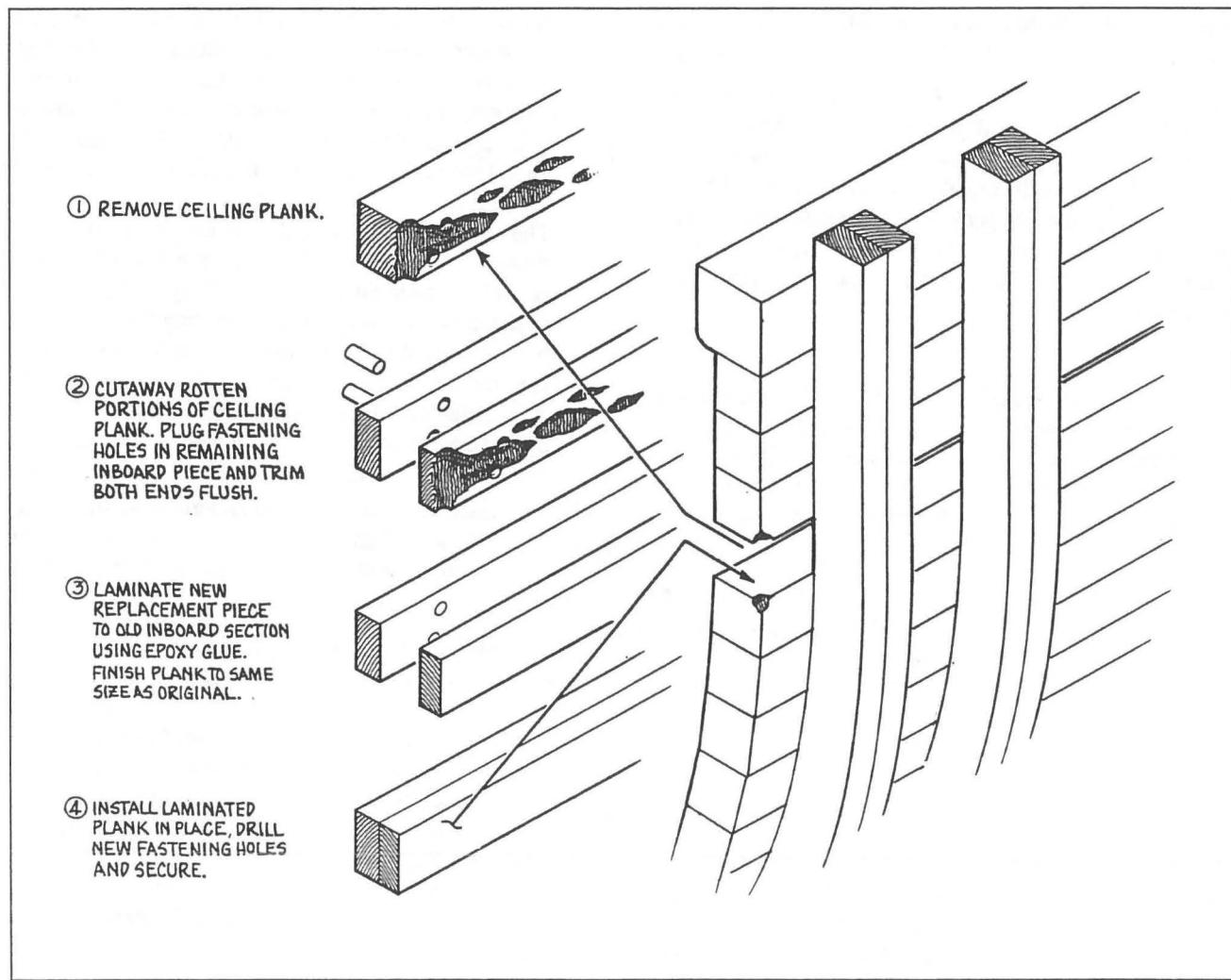
□ Knees

Based on survey data, it is estimated that 74% of the hanging knees can be preserved (34 out of 46) and that about half of the lodging knees in way of the hatches can be preserved (6 out of 12). An additional four new lodging knees will be needed to replace those removed by the United States Army.

The knees are "grown" (taken from the roots of Douglas fir trees so that their grain follows a curve of their finished shape) for added strength. Grown knees are no longer available through normal lumber sources and will probably be difficult to find in the large sizes required. The knees are typically comprised of a combination of dense, relatively rot-resistant wood, interspersed with areas of comparatively soft wood. In most instances, rot has oc-

Fig. 25. Ceiling plank reconstruction.

Graphic: M. Gillmore, Tri-Coastal Marine



curred in the soft wood, while the denser wood is left largely intact. This condition lends itself to the use of epoxy consolidation techniques which can fill in the gaps left by decay.

To preserve the knees, they would be removed by driving out the clench bolts fastening them to the deck beams, clamps, and ceiling. If the knees have nail sickness damage around the fastenings, the fastening holes would be drilled out and plugged with wood dowels bedded in epoxy, then re-drilled for new fastenings. Rotten areas would be repaired using epoxy compounds. While this sounds like a lot of work, the process may be less effort than milling and fitting new grown knees.

□ Deck Beams

The general condition of the deck beams in way of the main weather deck (frames #5-50) is illustrated in figure 26, p. 64. This condition has been caused by fresh water seeping through leaking deck seams, butts, and fastenings in way of the beams. The resultant decay has hollowed-out the beams, but left their external appearance largely unchanged. The deck beams are massive, being designed to support heavy deck cargoes, and probably retain sufficient residual strength to support the present deck loading. The deck beams should nevertheless be repaired to ensure safety, and to allow fastening of new deck planking.

The method of repair shown in figure 27 (p. 64) utilizes the W.E.R. System (Wood Epoxy Reinforcement) developed by the Association for Preservation Technology (Stumes 1979). The process would involve cutting out the rotten portion of the beam and inserting a Douglas fir filler piece bedded in a special epoxy. Theoretically this process could be performed with the beam in place, and with knees attached. In practice though, this approach may prove impractical. It should be anticipated that most beams would be removed for preservation.

The main deck aft of the quarter deck bulkhead is in relatively good condition, with the beams showing little decay. These deck beams, seven in all, can probably be left in place, along with much of the accommodation deck planking.

□ Waterway Timbers

The waterway timbers have lost much of their effectiveness as longitudinal strength members and are too severely decayed to be preserved. In-kind renewal is recommended, though it may be difficult to acquire timbers long enough to replace the midbody waterways, which are 97' between scarf. If timbers of sufficient length and quality cannot be found, an option would be to use timbers that are either glue-laminated or built up with

glued scarf. Use of such alternatives would not be visually apparent, and would be preferable to the loss of longitudinal strength and original construction details that would result from using shorter lengths of timber.

□ Main Deck Planking

Most of the deck planking on the main weather deck will have to be renewed in order to restore watertight integrity to the deck. Renewal of deck planking does not represent a significant loss of historic fabric; deck planks were routinely replaced throughout the working life of a wooden vessel. An exception to this is the planking in the aft accommodation, where plank renewal will necessitate removing several joiner bulkheads that are significant original fabric. Renewal of some of the deck planking at the forward end of the accommodations area cannot be avoided because most of the planking to be renewed on the main weather deck will have to extend aft of the quarter deck bulkhead in order to achieve a proper shift of butts.

Replacement planking should be in long lengths (some of the existing deck planks are in excess of 50' in length). Long planks will reduce the number of butts (which are common entry points for decay), and will increase hull strength. A planking plan should be developed in order to lay out a proper shift of butts for the main deck.

□ Bulwarks

The main bulwarks are extensively rotten and would be restored by renewing all of the stanchions, bulwark planking, and caprail. Many of the stanchions are original fabric, but are too deteriorated to be effectively preserved. In their present state, the stanchions are an entry point for rain water that is causing decay in the top timbers and upper ceiling planks.

Preservation of portions of the bulwark clamp would be optional, though it may prove difficult to remove intact. The pinrails are hardwood and can be salvaged. Also salvageable are the iron ringbolts in many of the bulwark stanchions. These should be repaired as needed, coated (galvanizing is not recommended for historical reasons), and installed in their original locations.

□ Quarter Deck

The quarter deck requires considerable work, but may not need to be completely disassembled for rebuilding. Rot is found variously in the deck, rails, trunk, and in the bulkhead at the break of the quarter deck. Most of these areas can be repaired in a piecemeal fashion.

Renewal of the deteriorated hull frames on the starboard quarter will require removal of the decking and rails along

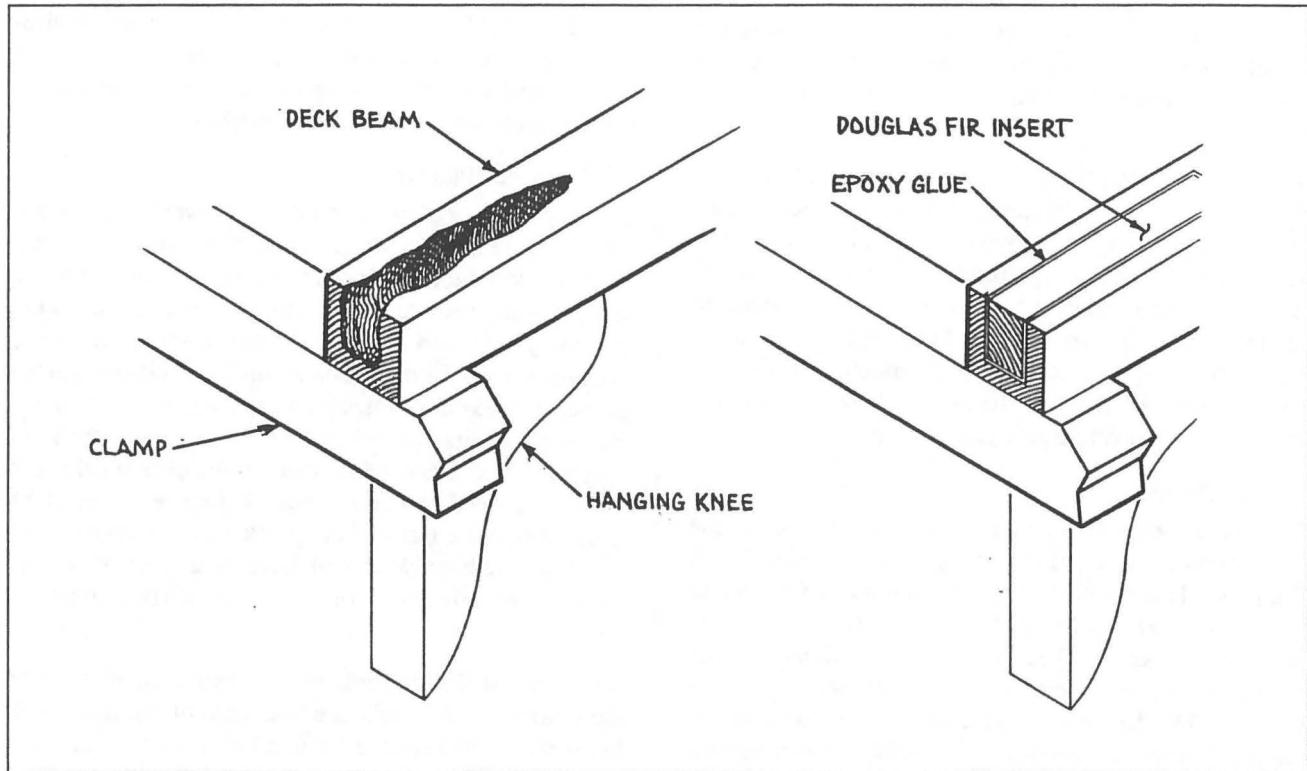


Fig. 26. and Fig. 27. Deck beam restoration.

Graphic: M. Gillmore, Tri-Coastal Marine

the starboard side, and the deck aft of the trunk will need to be taken up in order to replace rotten deck beams in way of the rudder trunk. The beam at the aft end of the cabin trunk may also have to be renewed, as well as several of the half-beams in way of the trunk.

The quarter deck bull rail and taffrail are rotten in local areas, but may be partially salvaged. If extensive rot is found in the margin planks beneath the bull rail, the rails will have to be removed, regardless of their condition. The quarter deck bulkhead is extensively rotten and would be renewed in its entirety, including the sill timber. The cabin trunk requires local repairs to rotten areas in the trunk sides, and the trunk top should be caulked (it is presently leaking into the accommodations below, a problem that should be addressed during the stabilization phase).

Leakage may have resulted in decay of the beams supporting the trunk top, thus necessitating the removal of the decking and renewal of one or more of the beams. In order to reduce the chance of damage to the joinery in the aft accommodations, an effort should be made to carry out repairs to the trunk without fully disassembling it.

▣ Forecastle Head Deck

The forecastle head deck is in fair condition and most of the appurtenances are in salvageable condition. There are

local areas of rot in the bull rails and in the ends of three of the deck beams. As with the quarter deck, the forecastle head could be left in place while the hull and main deck are being restored beneath it, though this would probably prove more trouble than its worth, particularly when it comes to renewing the rotten clamps (an extension of the bulwark inwales) and top timbers in way of the forecastle head.

The forecastle head deck beams are arranged in an odd fashion, butting into the clamps rather than resting on them in the usual manner. This arrangement will make it difficult to renew the clamps without dislodging the deck beams and everything resting on them.

Disassembly of the forecastle head deck is recommended. All deck planking would be renewed, as well as portions of the bull rail, and possibly one or more of the deck beams. All other items on the deck would be salvaged, including samson post, bitts, catheads, and capstan.

■ Treatment of Other Items

▣ Deckhouse

The deckhouse is in generally poor condition with extensive rot in the exterior sides and top. It must be removed from the deck in order to repair or replace the main deck

beams beneath, and will have to be at least partially disassembled, as it cannot be lifted off the deck in one piece. Only the forward end of the deckhouse is considered significant; the aft portion of the structure was rebuilt by the U.S. Army following the wartime use of the vessel as a barge. The Army work is inferior and does not follow the original arrangement.

The recommended treatment is to preserve the forward end of the house, while restoring the aft end to its former configuration. Physical evidence on the vessel indicates the original dimensions of the deckhouse (this is supported by documentation of a Bendixsen-built near-sister, the *Metha Nelson*), and structural details, such as the windows, are evident in the original structure at the forward end of the deckhouse.

The deckhouse interior should also be restored to its former arrangement. This would include eliminating the "Watchman's Room," enlarging the forecastle, and reducing the fore-and-aft dimensions of the galley and donkey room. Furnishings and appointments for the interior compartments should be based on a historic furnishings report or equivalent research.

□ Donkey Engine

The donkey engine is not original to the *C.A. Thayer*, but represents the type of machinery she would have had. It is a significant artifact taken from the schooner *Beulah*, a vessel of similar type and dimensions built in 1882.

The donkey engine is in fair condition, but has not been thoroughly preserved. The installation, begun in the 1960s, is incomplete; the machinery is not secured to the deck (as the original donkey engine must have been), and the piping and power linkages have not been installed to give the installation an authentic appearance.

The donkey engine will have to be removed for rebuilding of the main deck. While out of the vessel, it should receive any repairs needed for interpretation and preservation, and properly coated. It would then be installed in the rebuilt deckhouse, along with the appropriate auxiliary connections. Further research will be needed to ensure that the installation is historically accurate.

□ Fisherman's Forecastle

The fisherman's forecastle (not to be confused with the original crew's forecastle in the deckhouse) is comprised mostly of light joinery, which is in good condition. Unfortunately, all of this fabric must be removed in order to restore the hull in way of the forecastle. Most of the joinery, including bunks and bulkheads has been replaced in the post-historic period and is significant in form only.

It is recommended that the fisherman's forecastle be restored in its present configuration after completion of hull restoration. The forecastle should be thoroughly documented before disassembly, and existing joinery salvaged where possible.

The one suggested modification is to terminate the aft bulkhead at the forecastle deck level in order to increase ventilation to the enclosed space beneath this deck, an area prone to rot due to moist stagnant air.

□ Aft Accommodations

The aft accommodations consist primarily of interior joiner bulkheads and historic furnishings (the accommodations deck and cabin trunk have been addressed previously). Some of the bulkheads are original, while others are fabric installed during a restoration of the accommodations in the 1960s. In the interest of avoiding damage to the historic bulkheads, an effort should be made to keep portions of the accommodations area intact during the restoration. Of most importance are the panelled bulkheads between the companionway and the starboard side of the trunk, including those in the saloon and captain's cabin. The tongue-and-groove bulkheads in the mate's cabins and head on the port side are of less concern, as they are not historic fabric; removal of these bulkheads, if necessary to access the port quarter of the hull, would not present a problem.

The practicality of working around the accommodations area during restoration of the aft end of the hull is not certain, and disassembly may ultimately be necessary. Prior to any disassembly, the structure and furnishings should be thoroughly documented. Where historic bulkheads must be removed, care should be taken to preserve the false wood-grain finish; this type of finish is a lost art and would be difficult to replicate.

Consideration should be given to completing the restoration of one or more of the mates' cabins following completion of hull restoration. These cabins were left bare during the restoration of the 1960s, and have remained so since. The appropriate furnishings should be determined through a historic furnishings report.

□ Cargo Hatches

The fore and main cargo hatches are considerably altered from their original configuration as a result of modifications made by the U.S. Army in World War II. While the Army modifications might be considered significant, they impact a feature of greater significance, the historic arrangement of the main deck during the lumber schooner period (1895-1912). Restoration of the hatches to the original configuration is therefore recommended. This

would involve shortening the main hatch by 4' by terminating the aft end of the hatch at about frame #43, and lengthening the fore hatch by 7' by extending the forward end to frame #19. Lengthening the fore hatch would have to be done in conjunction with shortening of the deck-house to its former length; the house presently extends aft of the deck beam that originally marked the forward end of the hatch.

The structure of the hatches ranges from moderately to severely rotten and most elements would have to be replaced, including coamings, carlings, lodging knees, and perhaps some of the half-beams in way of the hatches. An attempt should be made to preserve the remaining lodging knees, despite their poor condition. A minimum of four new knees will be needed to replace those removed by the Army. Four full deck beams and three hold stanchions will also be needed to replace those removed during the modification.

Another step that could be taken to return the main deck to its original arrangement would be to restore the small hatch that was originally located forward of the deck-house. This hatch was probably used to access an orlop deck at the forward end of the hold, that would have served as a sail locker or for stowage of ship's stores. An accurate restoration of the hatch would be possible, based on existing physical evidence on the main deck.

■ Deck Equipment

Deck equipment includes the windlass, capstan, hand bilge pump, and steering gear (the donkey boiler and power winch have been addressed in a previous section). All of these items are historically significant, although the bilge pump was a later addition. The deck equipment will have to be removed for restoration of the decks, and should receive preservation treatment while out of the vessel. Recommendations for each piece are as follows.

Windlass: The windlass should be completely disassembled, sandblasted, and coated with anti-corrosive paint: inorganic zinc, followed by a conventional finish coat that will be easy to maintain. Any damaged or inoperative elements of the windlass should be repaired in order to return the windlass to fully-operational condition. This would include welded repair of the broken cross-head casting and chain pipe irons.

Capstan: The capstan is in good condition and will probably only require touch up of surface corrosion, and painting. Disassembly would be optional, but is recommended, as it would allow lubrication of interior moving parts.

Hand Bilge Pump: The hand bilge pump aft of the mizzen mast is presently inoperative and severely rusted. It should receive immediate stabilization to arrest ongoing corrosion. At the time of restoration, the pump should be restored to operating condition, sandblasted, and coated per the recommendations for the windlass. The missing bilge suction, formerly a single pipe running straight down from the pump to the bilge, could be replaced to allow use of the pump.

■ Spars and Rigging

Preservation of the spars and rigging will be straightforward. The spars are presently in good condition with only minor areas of damage or decay. The masts and bowsprit are less than ten years old and have considerable service life left in them if properly maintained.

Upon removal, the spars should be adequately supported to prevent warping. If the unpainted spars are to be stored in the open air, they should be covered to keep rain water out of open checks. Any damage to the masts should be repaired while they are rigged down. It is also recommended that the masts be treated with a fungicidal fumigant, such as Vapam. Fumigation will greatly extend the life of the masts.

The gaffs and booms are presently in good condition and will probably only require routine maintenance. The mizzen gaff, missing since the prewar era, should be reinstated, if this step has not already been taken by the time restoration begins.

The wire standing rigging retains sufficient strength to stay an inoperative rig, but should receive maintenance while rigged down. All wire should be stripped of its service and coated with a penetrating wire preservative. It would then be served with fresh marlin and coated with rigging tar.

If the rig is to be put into operation for any use other than setting staysails at the pier, it will need to be further upgraded. All of the mast fittings, chainplates, and stay anchors would need to be thoroughly inspected, and replaced if there is any question of integrity. Some of the more corroded shrouds would probably need to be replacement, as well as several of the chainplates. The mast partner timbers at the deck would need to be properly secured; they are presently held in place with undersized fastenings.

■ Restoration Site and Facilities

Most of the restoration work would take place with the vessel out of the water at a site within the Bay Area. The key component of the work site will be a dry dock or

graving dock that is available for a continuous period of at least eighteen months. Due to the state of the commercial marine industry in the area, such facilities are becoming increasingly scarce—at present, there are only two shipyards with suitable dry docks operating in the Bay Area. Neither of these yards have staff capable of undertaking wooden vessel repair of the magnitude of the proposed restoration.

An alternative would be to acquire a facility and perform the work as an in-house effort, or under contract with firms experienced in wooden ship repair. The most promising potential restoration site appears to be the Hunter's Point Naval Shipyard in San Francisco, where there are two graving docks that are no longer in regular use by the U.S. Navy. In addition to the docks, the site has sufficient storage space and an operational woodworking shop. The Hunter's Point facility would also be invaluable for carrying out cyclical maintenance on the large vessels of the historic fleet, particularly the ferry *Eureka* which, due to her extreme beam, has few alternatives for drydocking. The Maritime Park should pursue a long-term option for the use of one of the graving docks through an inter-agency cooperative agreement with the Navy; the future of the historic fleet should not be contingent on the tenuous survival of the local maritime industry.

If use of the Hunter's Point facility cannot be obtained, other options for drydocking *C.A. Thayer* include:

- Use of the Service's floating dry dock, AFDL-38, presently under lease to Pacific Dry Dock and Repair Company in Oakland, California. Limited use of this dock might be arranged through modification of the present lease agreement. If an agreement cannot not be made to use the dock at its present site, another waterfront site would be needed for berthing the dry dock.
- Acquisition and conversion of a barge for use as a temporary dry dock. A surplus barge might be acquired through the GSA. The necessary modifications would be an additional cost for the Maritime Park. This option would have the advantage of allowing the restoration to take place with the vessel/barge alongside the Hyde Street Pier, where the public could view the work in progress.

The basic requirements for a restoration facility would be as follows.

Dry Dock or Graving Dock: Minimum dimensions for the dock would be approximately 180' x 60' (no attempt should be made to lift the vessel with straps or on an inclined marine railway; such methods will place an excessive strain on the hull).

Storage Facilities: Most of the on-site storage facility can be little more than an open lot with enough space to store the lumber in stacks, and sufficient room to shift it with forklifts and cranes. A minimum space of 10,000 square feet should be set aside for the lumber, and for storage of spars and other items removed from the vessel. Tarps will be needed to protect the lumber during the winter months if open-air storage is used (long-term storage of the lumber for air-drying would probably take place at a location other than the restoration site). Covered storage will also be needed for smaller items, such as fastenings, supplies, and items removed from the vessel for preservation: rigging, fittings, and joinery. At least 3,000 square feet of space should be set aside for this purpose.

Shop Space: Extensive shop space will not be required; most of the working of heavy timbers is best done out of doors where the timbers can be handled with the use of forklifts and cranes. Some shop space will be needed for preservation work on items removed from the vessel, and for joinery, painting, and rigging work. The estimated requirements for enclosed shop space is 1,500 square feet.

☐ Equipment

The necessary equipment will include most of what a wooden shipbuilding yard would need. The following equipment will be essential to the restoration effort.

- 40" (or larger) tilting arbor shipsaw, 45 degree left and right, with carriage and roller arrangement suitable for working heavy timbers
- 12,000 lb. forklift
- 20-ton crane
- (2) 36" or 40" bandsaws
- Assorted hand and power tools
- Dunnage for blocking and shoring the vessel on dry dock
- Staging

Additional equipment that would expedite on-site work includes:

- 18" (or larger) thickness planer
- 12" jointer
- 10" table saw
- 200 cfm air compressor (for air tools)

☐ Services

- Electricity (3-phase 240 and single-phase 220/110 VAC) for dock, shop, and storage
- Fresh water (1-1/2" line for fire system)
- Site security
- Toilets

- Debris removal

An estimate of the start-up and overhead costs for a restoration facility can only be given in the most general terms. The major unknown is of course the site itself. This may range from a rent-free site to one costing well into the six-figure range for an eighteen-month lease. Equipment purchase and lease could be expected to cost in the range of \$80-120,000, while services would probably be in the range of \$30-60,000.

■ Materials

The list of materials required for restoration goes beyond the major lumber requirements discussed in Phase 1A, p.53. Items that will be needed in significant quantities include fastenings, smaller lumber for joinery work, preservatives, coatings, caulking materials, and seam compounds. In most cases, the materials used should be of the same type and quality as those originally used in the vessel. Exceptions to this "in-kind" policy may be encountered where like materials are no longer available, or where departures are justified in the interest of safety or where durability could be increased without adverse impact to historic integrity.

Sources can be found for most of the following materials, but some may require a long lead time to acquire. The following materials will be needed for in-kind replacement. In some cases, departures for original materials are recommended and are noted.

□ Fastenings

As much as 32 tons of iron fastenings and 22,000 linear feet of wood fastenings (trunnels) will be needed for a complete rebuilding of the hull. An example of the fastening requirements for the major structural members is given below. Developing a detailed inventory of fastenings will require further survey (as recommended for Phase I), and detailed scale drawings of the key structural connections and their fastening patterns.

Item	Fastening	Size	Lengths	Quantity
keelsons	clench bolts/drifts	1-1/8"	36" to 60"	1,000
clamps	" "	1"	24"	600
ceiling/knees	" "	7/8"	18" to 48"	6,000
ceiling	trunnels	1-1/4"	18" to 24"	8,000
hull planking	"	1-1/4"	12" to 16"	7,000
deck planking	ship spikes	3/8"	8"	4,000
hull planking	"	1/2"	10"	4,000

Clench bolts and drifts: If clench bolts cannot be found in the sizes required, they could be forged on site. Drifts can be cut out of round stock as needed. Clench rings will have to be purchased. Galvanized round

stock is recommended for drifts, but galvanized clench rings are not recommended where they would alter historic appearance. Use of threaded bolts is also not recommended; no threaded fastenings were used in the vessel's original construction.

Trunnels: The trunnels will have to be custom ordered. Sample trunnels should be removed from the hull to determine the type of wood (they were traditionally made of locust or oak). Each trunnel was wedged after being driven in; an equal number of hardwood wedges will therefore be needed.

All other fastenings should be available from manufacturers, though some may not be off-the-shelf items. Use of hot-dip galvanized fastenings should be used in all cases where they will not impact the original appearance.

□ Coatings

Traditional materials are recommended for both restoration and maintenance. The exception will be where the products are no longer available or where the superior protection of modern coatings has overriding importance, as in the case of anti-fouling bottom paint. The following are the recommended coatings.

Interior/exterior painted surfaces: Alkyd-based primer and finish gloss enamel (red-lead primer is recommended if available)

Interior/exterior unpainted surfaces: Non-pigmented wood sealer

Decks (exterior): Boiled linseed oil

Spars: Alkyd enamel on all painted surfaces, linseed oil or log oil on unpainted surfaces

Hull bottom: Oil-based high copper content bottom paint (if available)

□ Caulking and Seam Compounds

Traditional materials are recommended for seams. Where appropriate, modern bedding compounds or sealants could be used for faying surfaces where watertightness is required, though these products should be used with discretion. In some applications, synthetic compounds, such as silicon, polyurethane, and polysulfide, tend to promote rot because they do not allow the wood to "breathe."

Deck seams: Cotton and oakum (preferably Norwegian) payed with marine glue

Topsides Seams: Cotton and oakum payed with oil-based putty

Bottom seams: Cotton and oakum payed with pure portland cement

Uncaulked seams: Oil-based putty, Dolphinite (or equivalent oil-based bedding compound)

■ Preservatives

Extensive use of wood preservative is recommended during restoration in order to extend the life of both new and existing fabric. This treatment would be in addition to the rot treatment recommended for the stabilization phase, and any pre-treatment the new lumber would receive.

The variety of preservatives that are available fall into three categories: fumigants, water-soluble preservatives, and oil-based preservatives. The two major criteria for choosing among these preservatives are that they be safe to use, and that they be effective, in that order. Ruling out chemicals that are toxic to humans will unfortunately eliminate most of the more effective products. The difficulty will come in finding an effective preservative among the remaining safe products. The following are some possible options:

Fumigants: Fumigants, including Vapam and Chloropicrin, are effective in treating large timbers, which most other preservatives will not fully penetrate. The drawback is that the vapors produced by fumigants can be harmful if they become concentrated in poorly-ventilated compartments. Fumigants are therefore not recommended for use within the hull. They do have application for large timbers that are in the open air, such as the spars, bull rails, and bulwark stanchions. The spars would be treated with fumigants while out of the vessel; all other items would be treated after restoration work is completed.

Water-soluble preservatives: Nontoxic water-soluble preservatives include salt (sodium chloride) and Borax (sodium borate). These chemicals are less effective where there is frequent fresh water wetting that leeches them out of the wood.

Salt was traditionally used as a preservative (due to its hygroscopic qualities, salt was also used to keep topside and deck planking from drying out and leaking). In fact, the salt shelves, that were originally used for packing the spaces between frames with rock salt, still remain in *C.A. Thayer's* hull. The problem with salt is that it greatly accelerates corrosion of iron, particularly fastenings. Nevertheless, there would be some benefit in packing salt into the frames spaces during restoration.

The corrosive effects of the salt would be mitigated if galvanized drifts are used to fasten ceiling to frames, and if all futtocks and hull planking are fastened with trunnels, as they originally were. As a maintenance procedure, sea water wash-down of the decks will also be beneficial, if

all salt is rinsed off of iron deck equipment following wash-down.

Sodium borate has previously been discussed as a treatment for arresting decay in the stabilization phase (see the section "Phase 1B," p. 55). It could also be used for pre-treating new lumber, either by pressure treating, or with the diffusion process. Treatment would have to be performed at a treatment facility, unless the Service is willing to invest in the necessary equipment.

Sodium borate might also be substituted for rock salt in the frame spaces, though regulatory approval may be required for this application.

Oil-based preservatives: These preservatives are only useful for surface application, as they will not penetrate Douglas fir beyond a fraction of an inch. They are useful for protecting end-grain and for preventing the spread of decay to adjacent timbers. Another. About the only product that can claim to be reasonably nontoxic is copper napthenate (Cuprenol). Use of this preservative is recommended for treating new and existing timbers, but should not be used on timbers that require additional milling; breathing sawdust soaked in copper napthenate may be a health hazard.

The recommended application for the preservatives discussed above are as follows:

Fumigants (Vapam): Masts, bowsprit, bulwark stanchions, forward and after bull rails, samson post, bitts.

Salt: Rock salt in salt shelves.

Sodium borate: Pre-treating lumber; substitute for salt in frame spaces.

Copper napthenate: Surface application on existing and new lumber; treating all end-grain, including fastening holes.

■ Restoration Sequence

The sequence of steps necessary to complete the restoration of *C.A. Thayer* would be defined in a detailed restoration plan completed prior to beginning the work. The process can only be discussed in general terms at this time. Regardless of the level of planning, there will be a degree of uncertainty until the work begins. One reason for this is the fact that the condition of some of the key elements remains unknown. Another reason lies in the fact that the hull structure is so extensively fastened and thoroughly interlocked that the practicality of carefully disassembling

it in order to preserve certain elements can only be determined in practice. The following is a basic outline of the process.

□ Drydocking and Disassembly

Restoration of the hull would begin with drydocking. Although portions of the upper hull and decks could technically be renewed with the vessel afloat, it is not recommended as it could result in further distortion of the hull (the upper hull structure is crucial to longitudinal strength and a partially disassembled hull might not be able to resist bending strains, even in a calm-water berth).

Certain elements can be disassembled and removed for the vessel prior to drydocking. These include: rig, deck house, deck equipment, and the interior joinery and furnishings in the fisherman's forecastle and aft accommodations.

The method used for supporting the keel on dry dock will depend on whether an attempt will be made to remove existing hog. If so, adjustable blocks or splitting blocks would be used. Bilge blocks can be conventional, though they must be shifted periodically during the course of the work. Shoring and bracing will also be needed, both inside and out, to retain hull shape during disassembly and assembly.

Disassembly and renewal of the hull structure would progress in a stem-to-stern sequence, and from outside to inside, i.e. from planking to framing to ceiling. The ceiling would be left in place until a number of frames had been replaced, then removed plank by plank for renewal or preservation. During this process, extensive interior bracing and exterior shoring would be used to prevent the hull from losing shape.

A procedure will have to be developed for safely handling and disposing of the existing frames and other members that are coated with pentachlorophenol grease. This may slow the disassembly process considerably.

The restoration sequence will depend largely on the extent of renewal the backbone will require. If all or most of the keelsons must be renewed, it would be advisable to remove most of the longitudinal strength members (ceiling, clamps, waterways) at one time in order to allow the hog to settle out of the keel. Removing the hog has a practical, as well as aesthetic, justification; it will be difficult to bend the massive new keelson timbers to conform with a hogged keel.

A network, or flow chart, of the major restoration steps is shown in figure 28, p. 71.

□ Completing the Job

After the hull has been caulked and all exterior hull painting completed, the hull can be re-floated and the remainder of the work completed alongside a dock at the restoration site, or at the Hyde Street Pier. All work requiring crane lifts, such as installation of the rig, donkey boiler, and windlass, should be completed at the restoration site. The remainder of the work, including installation of electrical and piping systems, and restoration of the deckhouse, aft accommodations, and fisherman's forecastle, could be completed with the vessel back in her berth at Hyde Street. Some of this work will have interpretive value and can be performed with public viewing. The final step to restoration will be the installation of historic furnishings and interpretation.

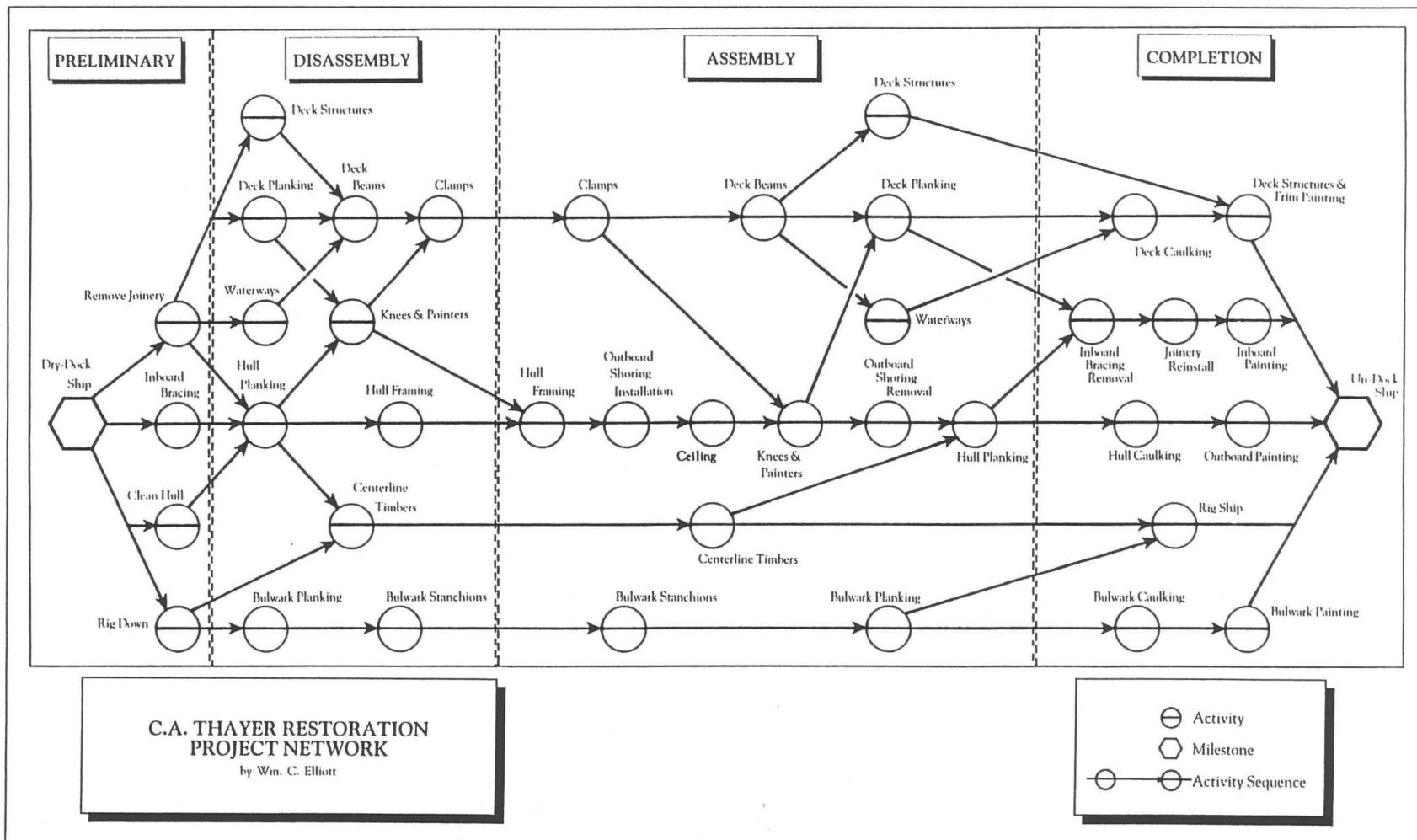


Fig. 28. C.A. Thayer restoration network proposal.

Graphic: Wm. C. Elliott, Tri-Coastal Marine

□ Estimate of Labor and Materials for Restoration

The following is an estimate of the labor required for restoration. The treatment specified for each element of the structure is based on known condition, and the probability that the element can be removed and installed without irreparable damage.

JOB DESCRIPTION	TREATMENT	QTY/UNIT	MAN HRS	MAN DAYS	CREW SIZE	WORK DAYS
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PRELIMINARY

Joinery, Remove	PRESERVE	ONE JOB	800	100		
Inboard Bracing	- N/A -	ONE JOB	640	80		
Carpentry Totals			1,440	180	10	18
Clean Hull						
Sandsweep	- NA -	2,000 SF	48	6	3	2
Rig Down	PRESERVE	ONE JOB	400	50	10	5
TOTALS			1,888	236	10	24

DISASSEMBLY, DECK

Deck Structures

Deckhouse	PRESERVE	6,000 BF	150	19		
Trunk Cabin	PRESERVE	4,000 BF	120	15		
Windlass	PRESERVE	ONE JOB	16		2	
Windlass Found.	SCRAP	300 BF	8	1		
Capstan	PRESERVE	ONE JOB	16	2		
Catheads	PRESERVE	240 BF	12	2		
Samson Post	PRESERVE	600 BF	30	4		
Bitts (6)	PRESERVE	150 BF	8	1		
Wood Cleats	PRESERVE	450 BF	24	3		
Fittings, misc.	PRESERVE	ONE JOB	80	10		
Deck Planking	SCRAP	27,000 BF	405	51		
Waterways	SCRAP	4,288 BF	150	19		
Beams & Stanchns	PRESERVE	20,000 BF	528	66		
Deck Clamps	SCRAP	7,450 BF	112	14		
TOTALS		70,478 BF	1,659	209	12	17

ASSEMBLY, DECK

Deck Clamps		7,450 BF	1,639	205		
Beams & Stanchns						
Main Deck Beams	RENEW*	16,404 BF	3,609	451		
Hold Stanchns	PRESERVE	2,887 BF	635	79		
Stanchn Clamps	RENEW	640 BF	141	18		
Focsl Beams	RENEW*	1,228 BF	270	34		
Poop Beams	RENEW*	1,680 BF	370	46		
Hatches & Partners						
Mast Partners	RENEW	1,440 BF	317	40		
Hatch Coamings	RENEW	3,613 BF	795	99		
Hatch Carlings	RENEW	1,512 BF	333	42		

JOB DESCRIPTION	TREATMENT	QTY/UNIT	MAN HRS	MAN DAYS	CREW SIZE	WORK DAYS
Lodging Knees	PRESERVE	320 BF	96	12		
Lodging Knees	RENEW	320 BF	192	24		
Waterways						
Main Waterway	RENEW	3,088 BF	679	85		
Wtrwy Blocking	RENEW	1,200 BF	264	33		
Poop Margins	RENEW	1,728 BF	380	48		
Deck Planking						
Main & Focsl	RENEW	22,000 BF	4,180	523		
Poop	RENEW*	2,230 BF	424	53		
Trunk, top	RENEW*	2,800 BF	532	67		
Deck Structures	PRESERVE	9,000 BF	1,840	230		
Windlass Fndm	RENEW	300 BF	66	8		
Poop Bhd Sill	RENEW	510 BF	112	14		
Poop Bhd	RENEW	1,632 BF	359	45		
TOTALS		81,982 BF	17,233	2156	20	108
<u>DISASSEMBLY, HULL</u>						
Outbd Planking	SCRAP	42,000 BF	630	79		
	PRESERVE	8,000 BF	400	50		
Knees, Pointers						
Hanging Knees	SCRAP	2,300 BF	46	6		
Hanging Knees	PRESERVE	9,200 BF	460	58		
Pointers	PRESERVE	1,345 BF	67	8		
Hull Framing	SCRAP	125,000 BF	4,375	547		
Centerline	SCRAP	30,000 BF	750	94		
	PRESERVE	22,000 BF	1,100	138		
Bulwark Plnkng	SCRAP	5,400 BF	81	10		
Bulwark Caps	SCRAP	6,900 BF	242	30		
Bulwk Pinrails	PRESERVE	ONE JOB	16	2		
TOTALS		252,145	8,167	1022	25	41
<u>ASSEMBLY, HULL</u>						
Framing	RENEW	143,840 BF	25,891	3236		
Outbd Shoring	TEMPORARY	ONE JOB	400	50		
Thick Ceiling						
Remove	PRESERVE	20,250 BF	1,215	152		
Laminate	PRESERVE	20,250 BF	1,620	203		
Install	PRESERVE	20,250 BF	4,455	557		
Remove	SCRAP	6,750 BF	101	13		
Install	RENEW	6,750 BF	1,485	186		
Thin Ceiling						
Remove	SCRAP	12,000 BF	180	23		
Install	RENEW	12,000 BF	1,584	198		
Knees, Pointers						
Hanging Knees	RENEW	2,300 BF	1,380	173		

* Can possibly be preserved, in whole or in part

JOB DESCRIPTION	TREATMENT	QTY/UNIT	MAN HRS	MAN DAYS	CREW SIZE	WORK DAYS
Hanging Knees	PRESERVE	9,200 BF	2,024	253		
Pointers	PRESERVE	1,500 BF	333	42		
Outbd Shore, Remv	- NA -	ONE JOB	100	13		
Outbd Planking						
Sheer to Garbd	RENEW	49,000 BF	13,720	1715		
Transom	RENEW	1,200 BF	336	42		
Bulwarks						
Blwk Planking	RENEW	4,080 BF	680	85		
Blwk Clamp	RENEW	1,300 BF	216	27		
Blwk Cap Rail	RENEW	2,600 BF	433	54		
Blwk Pinrails	PRESERVE	ONE JOB	48	6		
Focscle Bull Rail	RENEW*	1,100 BF	330	41		
Poop Rails						
Bull Rail	RENEW*	1,820 BF	546	68		
Rail Cap	RENEW*	1,040 BF	312	39		
Taff Rail	RENEW*	337 BF	101	13		
Centerline Timbers						
Stem	RENEW*	3,200 BF	711	89		
Apron	RENEW*	1,350 BF	272	34		
Keel	PRESERVE	9,000 BF	810	101		
Wormshoe	RENEW	1,350 BF	243	30		
Keelson	RENEW*	4,200 BF	378	47		
Rider Keelson	RENEW	3,800 BF	342	43		
Sistr Klsns (2)	RENEW	10,665 BF	960	120		
Sistr Klsns (2)	PRESERVE	10,665 BF	960	120		
Mast Step Tmbrs	RENEW	384 BF	106	13		
Deadwood	RENEW*	4,050 BF	1,114	139		
Sternpost	PRESERVE	2,016 BF	336	42		
Rudder Trunk	PRESERVE	850 BF	120	15		
Rudder & Stock	PRESERVE	?	320	40		
TOTALS		369,097	64,162	8022	40	201

COMPLETION

Caulking	- NA -					
Hull & Blwks		10,000 LF	1,200	150		
Decks		20,000 LF	1,800	225		
Caulking Totals		30,000 LF	3,000	375	12	31
Rig Ship	PRESERVE	ONE JOB	2,000	250	10	25
Painting	- NA -					
Outboard		ONE JOB	1,700	213		
Bulwarks		ONE JOB	800	100		
Deck Trim		ONE JOB	1,000	125		
Inboard		ONE JOB	600	75		
Painting Totals		ONE JOB	4,100	513		6
Inbd Shore, Remv	- NA -	ONE JOB	200	25		
Joinery, Install	PRESERVE	?	3,000	375		
Carpentry Totals			3,200	400	10	40
TOTALS			12,300	1538		

JOB DESCRIPTION	TREATMENT	QTY/UNIT	MAN HRS	MAN DAYS	CREW SIZE	WORK DAYS
PROJECT TOTALS						
LABOR						
Carpenters			95,86	11,989		
Caulkers			3,000	375		
Riggers			2,400	300		
Painters			4,148	519		
Total Man Hrs			105,409			
Total Man Days				13,183		
Average Crew/Days					50	
Estimated Project Duration						264

TOTALS OF MAJOR MATERIALS

Lumber, New	389,500	Board Feet
+15% (for damage and wastage)	58,425	
Total Lumber	447,925	Board Feet
Fastenings	32,000	Pounds
Paint	340	Gallons
Wood Preservative	160	Gallons

Estimated Cost of Restoration

A range of cost for restoration can be calculated using the labor and material quantities given above, and factoring in anticipated unit costs. The cost of labor, the greatest project expense, will vary substantially depending on the approach taken to the project. The unit price for labor given below could be achieved with a combined in-house and contract work effort, using independent (non-shipyard) contractors in a facility provided by the National Park Service.

If the restoration phase of the proposed treatment does not begin for eight to ten years, as expected, inflation could result in a sizable increase in overall cost for that phase. All cost given below are rounded to the nearest thousand.

ITEM	QUANTITY/UNIT	UNIT PRICE	COST
Labor	105,409 Man Hrs.	\$30-40	\$3,162,000-4,216,000
Lumber	447,925 Board Ft.	\$3-4	\$1,344,000-1,792,000
Fastenings	32,000 Pounds	\$0.80-1.5	\$26,000-48,000
Paint	340 Gallons	\$20-30	\$7,000-10,000
Preservative	160 Gallons	\$20	\$3,000
Other (caulking, wire rope, fittings)			\$30,000-60,000
Total Materials and Labor			\$4,572,000-6,129,000



■ Cost Estimates and Implementation Schedule

The major elements of the recommended treatment are listed below in general order of priority for implementation. The cost estimates given are considered sufficiently accurate for initial planning purposes, but may be affected by many factors, including changes in the technical approach or scope of work based on the results of further survey and analysis. Phase II costs may increase substantially due to the cumulative effects of inflation over the extended before restoration would begin.

Phase I

Survey/Analysis:

Hull Loading Analysis	\$ 15,000
Analysis of Decay	4,000
Structural Survey	66,000
Initial Lumber Acquisition	180-240,000

Stabilization:

Electrical System Overhaul	30,000
* Wood Preservative Treatment	35,000
* Erect Weather Covers	25,000
* Ballast/Buoyancy/Stiffening	40-225,000

Total Phase I \$ 395-640,000

Phase II

Restoration:

Planning	\$ 150-300,000
Site Prep. and Operation	180-270,000
Materials	1,430-1,532,000
Labor	3,162-4,216,000

Total Phase II \$ 5,022-6,318,000

Total Cost of Treatment Over Ten-year Period \$ 5,264-6,655,000

Although project scheduling will be relatively undefined, pending further planning, the following constrains are recommended:

- Phase I should begin immediately and should be completed within the next two fiscal years.
- Planning and materials acquisition for Phase II should be well underway by the time Phase I work is completed.
- An eight-to-ten year waiting period will be required for air-drying of some of the lumber required for restoration. Lumber requiring the longest drying time should be ordered as soon as possible. Acquisition of other materials can progress at a steady pace during the waiting period.
- Once begun, restoration should be completed within a two-year period.

Project costs spread over a ten-year period would be as follows:

FY 91: Phase I Work	\$ 196-318,000
FY 92: Completion of Phase I	196-318,000
FY 93: Phase II Planning/Materials Acquisition	263-305,000
FY 94: " " " " "	263-305,000
FY 95: " " " " "	263-305,000
FY 96: " " " " "	263-305,000
FY 97: " " " " "	263-305,000
FY 98: " " " " "	443-575,000
FY 99: Begin Restoration	1,581-2,108,000

FY 00: Complete Restoration 1,581-2,108,000



■ Impact of Proposed Treatment

The intended goal of the proposed treatment, and the justification for it, can be summarized as follows.

The proposed treatment is intended to preserve *C.A. Thayer*'s structural form and method of construction, and to do so using materials that closely match her existing fabric. This is seen as the only means of preserving the historic integrity of the vessel over the long term, and is based on the fact that her existing fabric, almost exclusively softwood, cannot be preserved indefinitely in an exposed environment.

Restoration will have a major impact on *C.A. Thayer*, but can be viewed as a "lesser of evils," to take no major action would result in the eventual disintegration of the vessel, or loss of historic integrity as a result of endless stopgap repairs. To remove the vessel from the water would result in loss of historic context and would not guarantee her long-term survival.

The impact of the proposed treatment on specific elements of the vessel would be as follows:

□ Hull

On the positive side, the hull would be returned to a seaworthy condition wherein it could be preserved for many years, possibly matching or exceeding its present life span of nearly one hundred years, with little more than consistent routine and cyclical maintenance. When *C.A. Thayer* must again be rebuilt at some time in the distant future, those disassembling her would find a hull very nearly identical to the one launched in 1895.

On the negative side will be the significant loss of historic fabric. At present, the hull is believed to be about 80-90% historic fabric (by volume). Even if attempts to preserve the backbone, ceiling, knees, and deck beams are successful, the hull will retain no more than 20-30% historic fabric after restoration. Renewal of much of the structure, including framing and hull planking, would result in little

or no visual impact. On the other hand, renewal of the ceiling in the hold would result in the loss of the seasoned appearance of the existing ceiling and would give the interior hull a "new" appearance. This may be avoided if the existing ceiling can be effectively preserved.

□ Decks and Bulwarks

Almost all of the existing fabric on the main deck would be renewed in the process of restoring the deck and bulwarks to watertight condition. A new deck will be more in keeping with the appearance and function of the vessel during her working life than would the existing deteriorated and leaking deck. The bulwarks will lose most of the seasoned appearance they have gained over many years of service.

Restoration of the fore and main cargo hatches to their original dimensions will improve historic integrity by returning the main deck to the configuration it is known to have had during the lumber carrying period.

□ Deckhouse

The recommended rebuilding of the deckhouse to the original plan and interior layout will result in a net improvement in historic integrity. The present arrangement is not representative of any historic period. The existing fabric that would be lost in the process dates from a period of lesser significance (the postwar rebuilding to resumed codfishing), and much of this is too deteriorated to be preserved in any case.

□ Fisherman's Forecastle and Aft Accommodations

These are essentially intact and require no restoration, but will have to be removed, at least in part, during restoration. They should not suffer any adverse impact if properly documented and faithfully restored.

□ Rig

The rig will undergo little change, with the exception of the installation of a mizzen gaff, a step that will restore the rig to its original exclusively gaff-headed arrangement.



■ Recommendations for Further Study

The Historic Structure Report should be considered only a starting point for the considerable research and planning that will be needed to successfully preserve *C.A. Thayer* over the long term. Many of the more pressing needs in this area were discussed in the section "Proposed Treatment." These include:

- Analysis of hull loading
- Analysis of decay
- Additional structural survey
- Investigation of the availability of lumber
- Investigation of methods for chemical treatment of decay
- Identification of a suitable restoration site

The following work is also recommended:

□ Investigation of Preservation Technology

State-of-the-art technology for the preservation of deteriorated wood may have useful application in the preservation of historic fabric in *C.A. Thayer*. Structurally deficient members could possibly be retained using techniques such as the wood-epoxy-reinforcement system described in "Hull Restoration," p. 59. The range of options currently available in this area of technology should be investigated further. If promising products or techniques are identified, tests should be conducted using representative samples of partially-deteriorated Douglas fir.

□ Further Documentation Of Existing Structure

Thorough documentation of *C.A. Thayer*'s existing structure will be essential in order to maintain historic integrity through the restoration process. The general arrangement drawings produced for the Historic Structure Report are a starting point. In addition to photographs and written de-

scriptions, the following measured scale drawing are recommended:

- Hull lines
- Ceiling plank expansion
- Hull planking expansion
- Deck planking plan
- Cross sections in way of forepeak, fisherman's forecastle, aft accommodations, and counter
- Framing plan showing arrangement of futtocks at various station of the hull
- Structural details of all major hull connections, including size and arrangement of fastenings
- Details of fisherman's forecastle and aft accommodations in plans and photographs
- Detailed rigging plan

□ Historic Research of Deckhouse and Other Deck Structures

Restoring the deckhouse to its original arrangement, as recommended, will require further research to accurately establish the design and location of windows, doors, bulkheads, and skylights. Other deck structures that are believed to have existed during the lumber carrying period could also be investigated for possible reconstruction. These include items identified in oral histories given by former crew members: fore hatch (with scuttle), paint and lamp lockers beneath the forecastle head, deck pump abaft the main mast, and numerous rigging details. A substantial body of information is available for researching these subjects at the Historic Documents Department of the SFMNH.

□ Historic Furnishings Report

Restoration of crew's quarters (forecastle and cook's cabin in the deckhouse, and mates' cabins in the aft accommodations) should be preceded by a Historic Furnishings Report as described in NPS-28 (National Park Service 1985). The furnishings and appointment appropriate to these compartments would be determined through this research document.



SCHOONER *C.A. Thayer*

Historic Structure Report 1991
Appendices

■ Bibliography

□ Physical History References

The majority of sources for the Physical History were obtained from the Historic Documents Department of the San Francisco Maritime National Historical Park in San Francisco, California. Most of the reference material is to be found in the “Wheelhouse Files” of former Superintendent of Ships Harry Dring. This material consists of Museum correspondence and records of work kept by the maintenance department, including contracts and invoices for work performed. Other reference material from the SFMNH includes published works, periodicals, and photographs.

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Roger Olmsted of the San Francisco Maritime Museum was responsible, along with Museum Director Karl Kortum and Harry Dring, for the initial research and planning for the acquisition, restoration, and interpretation of *C.A. Thayer*. This work resulted in several reports to the State of California Division of Beaches and Parks, compiled in three volumes at the Library of the San Francisco Maritime National Historical Park. This work also resulted in the small paperback volume, illustrated with photographs, cited above. His works are considered to be authoritative.

San Francisco Maritime Museum. 1960. Memorandum: Schooner *C.A. Thayer* — Cabin Restoration, 8 March.

A well-researched and reliable document presenting a plan which was in fact carried out.

San Francisco Maritime State Historical Park. 1961. Bid Specification for drydocking.

_____. 1964. Invitation to Bid for drydocking.

San Francisco Maritime National Historical Park. Photo No. E3.8495n, dated 1903. Uncredited.

A clear and complete view of vessel stranded high and dry on beach at Gray's Harbor.

_____. Photo No. F16.35.380n. Photo from *Seattle Times*.

Clear aerial view of vessel careened on beach.

_____. Photo No. J9.23.813n, dated 1914. Uncredited.

Reliable documentation of former existence of square yard and sail.

_____. Photo No. K9.38806n, 1957, Karl Kortum.

_____. Photo No. P78-086a, dated 1950. Uncredited.

Clear view of vessel in codfishing configuration. Reliable as to features shown.

_____. Photo No. F9.17856n, undated. Uncredited.

Clear and reliable as to features shown.

_____. Photo No. F16.35380, undated. Uncredited.

Clearly shows altered bowsprit (sprit and jibboom).

Tri-Coastal Marine. 1987. "C.A. Thayer Conditional Survey" and "Survey Data."

A detailed structural survey of the vessel that also noted evidence of physical alterations.

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_____. 1985. *Cultural Resources Management Guidelines, NPS-28, Release No.3*. Washington, D.C.: U.S. Government Printing Office.

Stumes, Paul. 1979. "Structural Rehabilitation of Deteriorated Wood" In *W.E.R. System Manual*. Ottawa: Association of Preservation Technology.

A manual describing techniques for preserving timbers in historic structures, with list of products appended.



■ Record of Test Borings

The following is a record of test borings taken in major timbers of the historic schooner C.A.THAYER during survey in 1988. Borings were taken using a 1/2" auger bit. Fibers were inspected and catalogued at various depths, thus giving an indication of the location of decayed fiber within each timber.

Condition of fibers was assessed based on appearance and is given as follows:

"good" Fibers appears normal, no visible evidence of decay. Timber is still sound in this particular area

"fair" Fibers are altered in appearance, possible incipient decay. Condition of timber is questionable.

"poor" Obvious evidence of decay and weakening of timber.

<u>ITEM</u>	<u>LOCATION</u>	<u>CONDITION</u>
LONGITUDINALS		
Bow Deadwood	frame 3	Fair to 4", dark fibers Good from 4" to 8", dry and light in color Poor from 8" to 16", dark and powdery
Bow Pointer, #2	port, 2ft. off centerline	Good to 10"
Upper Sister Keelson	port, frame 16	Good to 10"
Upper Sister Keelson	stbd, frame 16	Fair to 9", light in color
Upper Sister Keelson	port, frame 32	Good to 5"
Upper Sister Keelson	stbd, frame 32	Good to 4" Fair from 4" to 9" Poor from 9" to 16", dark powder
Upper Sister Keelson	stbd, frame 48	Fair to 14", some dark fibers
Lower Sister Keelson	port, frame 16	Fair to 6", dark Poor from 6" to 12", dark and mushy
Lower Sister Keelson	stbd, frame 16	Soft to 2" Fair from 3" to 5" Soft from 5" to 10", dark and moist
Lower Sister Keelson	port, frame 32	Fair to 4" Poor from 4" to 8", dark and mushy Fair from 8" to 12"

<u>ITEM</u>	<u>LOCATION</u>	<u>CONDITION</u>
LONGITUDINALS cont.		
Lower Sister Keelson	stbd, frame 32	Fair to 3" Poor from 3" to 9", dark and semi-soft Fair from 9" to 12", dark
Lower Sister Keelson	port, frame 48	Soft to 4" Poor from 4" to 8", dark and mushy Soft from 8" to 12"
Lower Sister Keelson	stbd, frame 48	Fair, dark and moist
Rider Keelson	Frame 33-34	Good to 12", except for rot pocket 4" to 8"
Rider Keelson	frame 49, under mizzen heel	Fair to 10", semi-soft Good from 10" to 16"
Stern Deadwood	frame 60	Fair to 6" Nail sickness from 6" to 14"
Sternpost		Good to 6"
FRAMES		
Frame	port, frame 4, 4th sheathing strake	Good to 6"
Frame	stbd, frame 4, 4th sheathing strake	Good to 4"
Frame	port, frame 16, 4th sheathing strake	Poor to 4", dark and mushy Fair from 4" to 8"
Frame	port, frame 16, strake #5	Poor, no shavings
Frame	stbd, frame 16, strake #5	Poor, no shavings
Floor, fwd futtock	stbd, frame 16, 1st sheathing strake	Poor from 1" to 7", dark and moist Fair from 7" to 8"
Frame	stbd, frame 17, strake #10	Poor, all dark powder
Frame		Poor from 4" to 8", dark and mushy
Frame	port, frame 32, 1st sheathing strake	Fair to 9", grey and semi-soft
Frame	port, frame 32, strake #1	Poor to 5", dark and mushy
Frame	port, frame 32, strake #9	Poor, dark and mushy
Floor	stbd, frame 32, 18" c.b. klsn.	Poor, dark and mushy

<u>ITEM</u>	<u>LOCATION</u>	<u>CONDITION</u>
FRAMES cont.		
Frame	stbd, frame 32, strake #1	Poor, grey and semi-soft
Frame	stbd, frame 32, strake #10	Poor to 5", dark and mushy
Frame	port, frame 48, strake #2	Poor, no shavings
Frame	port, frame 48, strake #8	Poor, dark fibers, no resistance past 2"
Frame	stbd, frame 48, strake #1	Poor, no shavings
Frame	stbd, frame 48, strake #2	Poor to 8", dark and mushy
Frame	stbd, frame 48, strake #8	Poor to 6", dark and mushy
Frame	port, frame 60, 1st sheathing strake	Good, most fibers lost during extraction
Frame	stbd, frame 60, 1st sheathing strake	Poor, soft powder
CEILING and SHEATHING		
Sheathing	port, frame 4, 4th sheathing strake	Good all thru
Ceiling	stbd, frame 4, 4th sheathing strake	Good to full depth
Sheathing	port, frame 16, 4th sheathing strake	Good
Ceiling	port, frame 16, strake #5	Fair to 4", fibers dry and sound Poor beyond 4", totally disintegrated.
Sheathing	stbd, frame 16, strake #3	Soft and mushy to 1/2"
Ceiling	stbd, frame 16, strake #5	Fair to 4", dark Fair from 1/2" to 3-3/4"
Ceiling	stbd, frame 17, strake #10	Good to 1" Poor from 1" to 8", Dark powder
Sheathing	port, frame 32, 1st sheathing strake	Soft, saturated
Ceiling	port, frame 32, strake #1	Fair to 2" Poor from 2" to 5", semi-soft
Ceiling	port, frame 32, strake #9	Fair, fibers dark but dry and sound
Sheathing	stbd, frame 32, 1st sheathing strake	Fair, dark and semi-soft
Ceiling	stbd, frame 32, strake #1	Fair to 4" Poor from 4" to 8", soft and mushy

<u>ITEM</u>	<u>LOCATION</u>	<u>CONDITION</u>
CEILING and SHEATHING cont.		
Ceiling	stbd, frame 32, strake #10	Fair to 1" Poor from 1" to 8", semi-soft to mushy
Ceiling	port, frame 42, strake #2	Fair, light in color, moist
Ceiling	port, frame 48, strake #2	Fair to 4" (inner plank) Poor from 4" to 8"
Ceiling	port, frame 48, strake #8	Good to 4" Poor from 4" to 8", dark powder
Ceiling	stbd, frame 48, strake #1	Fair to 4" Poor from 4" to 8", dark, semi-soft
Ceiling	stbd, frame 48, strake #8	Fair to 4", light colored Poor from 4" to 8", mushy
Sheathing	port, frame 60, top sheathing stake	Good
Sheathing	stbd, frame 60, top sheathing strake	Fair, dry and light in color

■ Draft Survey Excerpt

[Excerpted from the draft survey report "Preserving the Schooner C.A. Thayer" prepared for San Francisco Maritime National Historical Park by Morris Guralnick Associates, Inc., San Francisco, California. The report was based on a C.A. Thayer Board of Survey convened in San Francisco on February 22, 1991. Mr. Don Birkholtz, Mr. Maynard Bray, Mr. John Carter, Mr. Jack Ehrhorn, Mr. Fred Fisher, Mr. Dana Hewson, Mr. Harold D. Huycke, Mr. Karl Kortum, Mr. Doug Lee, Ms. Linda Lee and Mr. Harold Sommer sat on the survey committee. Included here are the report sections "Immediate Preservation," "Short Term Preservation," and "Long Term Preservation." The report's four appendices, although not reproduced, also contain useful information, including a detailed provisional lumber list.]

□ Immediate Preservation

Although the biggest danger that *C.A. Thayer* faces is deterioration and decay, a sudden catastrophic loss due to sinking or fire is possible. The probability of these events occurring may be low, but the outcome of either could be disastrous. The NPS should have the proper equipment and a plan to deal with these emergencies.

■ Sinking

The hull of *Thayer* is generally in such bad condition that the NPS is unable to keep it watertight even in the protected environment of the Aquatic Park. Leaks in the hull have developed spontaneously, some large enough to require emergency drydocking. In addition, the topside planking has deteriorated to the degree that it lets in rain. As the hull disintegrates, the likelihood of having large leaks increases. The vessel has a tight wooden ceiling covering the frame bays. This kind of construction makes it very difficult to discover leaks or deal with them at all from inside. The bilge pumping system has just been adequate to deal with previous leaks but it is unable to handle certain emergency situations.

Problem areas with *Thayer*'s bilge system and the National Park Service's procedures for dealing with emergency leaks are:

- The bilge pump (10") is old and isn't easy to operate as it's not self priming. The make and capacity are not known nor is its condition.

- The pump and strainer are in the locked forepeak. Pumps of this type can be easily clogged with debris.
- There is a single float type bilge alarm connected to a deck alarm and by telephone line to a guard agency. This line has been disconnected since February, 1991.
- Most emergency personnel are untrained in location and operation of the emergency bilge pumps.

These problems could allow the vessel to sink. One can easily imagine a mooring line parting on a windy night (as it did in both 1981 and 1982) and *Thayer*'s chafing against the pier, starting a leak in her hull. As she slowly settles in the water, non-watertight seams are submerged and the rate of sinking increases. The bilge alarm fails to work, is not heard, or the leak is simply too large for the pumps to handle. This is not a cheering scenario, but it is very possible.

In addition, MGA's preliminary assessment of the damaged stability indicates that *Thayer* will lose positive stability sometime after the centerline keelson structure is submerged. (The principal loss comes from the bilge water sloshing from side to side in the hold. Anyone who has tried to balance a shallow tray full of water will intuitively understand this effect.) The exact point at which this total loss of stability will occur can't be determined without further study and tests. However, it will happen at some point in the flooding. In this case, she could capsize at the dock in addition to simply sinking.

New procedures to cover leaking and the possibility of sinking should be implemented for *C.A. Thayer* by the NPS. They should include:

- Regular testing of the bilge alarm system and emergency procedures.
- Unlocked or easy access to the bilge pump by emergency workers.
- Regular inspection of the pump and the pumping system.
- Emergency workers who know the location of high capacity bilge pumps and are trained in their use on all the museum vessels.
- A daily pump out log for *C.A. Thayer*.

■ Fire

The immediate danger of an electrical fire is past due to recent repairs. In general, the NPS and all emergency personnel are better prepared to prevent and handle fire than they are sinking. *Thayer* is built from flammable materials, there is an operating oil fired stove on board and it is alongside a very flammable pier. Mainly, the fire prevention procedures of the NPS appear to be adequate

for the protection of the vessel. However, there are certain problems that should be addressed.

- There is no fire station on the pier. The closest hydrant is at the foot of Hyde Street. This will greatly delay the effective response to any serious fire.
- Like the bilge alarm, the heat and smoke detectors have been disconnected from the monitoring agency since February, 1991.

□ Short Term Preservation

C.A. Thayer is currently in very poor condition. The wooden hull and deck are extremely decayed and getting worse. The present level of maintenance is not sufficient to keep the vessel from rotting. If the status quo continues, *Thayer* will deteriorate to the point where she can no longer be kept afloat, much less continue as a floating exhibit. Unless she is rebuilt or the deterioration is stabilized, she is not likely to remain safely afloat past the end of this decade.

The goal of any short term preservation plan should be to stabilize the vessel and slow the rate of decay until she can be rebuilt or preserved out of the water. If nothing is done to arrest it, the decay will continue until there is no rebuildable structure. Different parts of the hull structure deteriorate in different ways: fastenings rust, caulking loosens, wood dries and suffers ultra-violet decay. However, the worst type of deterioration and the source of the structural problems on *C.A. Thayer* is dry rot. Unless it's arrested, the vessel will continue to decompose, like a fallen tree in the forest, until there is nothing left. Any short term preservation plan must address the causes and prevention of dry rot.

■ Wood Decay and Preservation

There are many organisms which cause wood to decay. For the most destructive of them, wood is food. Termites cause tremendous structural damage every year in the U.S. by eating into the foundations of houses. Ships and marine pilings are attacked by ship borers which, as their name implies, rapidly bore themselves into the wood. What is generally called rot is caused by the action of various species of fungi consuming the wood. There is soft rot, wet rot, dry rot, white rot—all of these are names for wood decay caused by different types of fungi. Generally, the most destructive in wooden vessels is the common brown or dry rot.

Fungi need moisture and oxygen to live. Serious rotting occurs only when the wood fibers are saturated. (This means that the rot fungi don't prosper unless the moisture

content is between 30 and 80 percent, which unfortunately is the approximate moisture content of the wood everywhere in *C.A. Thayer*. Actually, rot doesn't occur at all if the wood is deprived of oxygen by being continuously immersed. That's not saying that wood does not deteriorate without oxygen; strength is slowly lost to the action of anaerobic bacteria. Also, the structure of wood changes during long immersion in water.) Wood which is subjected to periodic wetting and drying, like the waterline region of a wooden ship, is particularly prone to dry rot.

Wooden ships in colder environments are less likely to suffer from dry rot than identical vessels in a warmer climates, as the absorption of water and the growth of the fungi are dependent on the temperature. Decay ceases when the temperature drops below 35F or goes above 100F. Also, vessels which are used continuously in the ocean are less likely to rot as a certain amount of salt is absorbed into the wood which helps preserve it. These are the conditions that changed for the worse when *C.A. Thayer* ended her working life at sea and became an exhibit in San Francisco. Rot fungi are everywhere in the environment and are transported (mostly by water) into the wood when the tree dies. Then the rot and deterioration of the wood begin. Rot fungi only flourish in the proper conditions. Unfortunately, these are the conditions prevailing on *Thayer*.

The topside hull planking and deck of *Thayer* have not been watertight for a long time. Rain and fresh water from deck washing have been leaking in and carrying rot fungi deep into the structure for years. As the fungus grows, it permeates the wood with microscopic strands. When it matures, it fruits and sends its spores to other uninfected parts of the wood. In a way, it is very similar to the spread of a mortifying disease like leprosy—the disease spreads from infected to non-infected areas. The topside heats in the sun all day and provides the warm and moist environment that is perfect for the dry rot fungi to thrive.

■ Wood Preservatives

Wood preservatives can arrest the decay of wood if they are present in sufficient concentration to kill the fungi or inhibit their growth. To be effective, the preservatives must be everywhere the fungi are, i.e., throughout the wood. Preservatives in heavy petroleum bases (typically pentachlorophenol and creosote) are not absorbed by wood in any real way at normal pressures. They are not useful for wet woods. (They work by providing a physical barrier and killing any fungi on the surface of the wood. They may have some use in new construction.) Pentachlorophenol was a popular preservative for ships. However,

its use is now restricted by the EPA as it is very poisonous to humans. There is a whole class of inorganic salt wood preservatives. The most commonly used is copper chromium arsenate. CCA is made to penetrate the wood by immersing the wood in a high pressure bath which also causes it to be fixed in the structure of the wood. CCA is also very toxic. Pressure treatments are obviously not useful for existing structures. Merely painting CCA or any preservative on the surface of wood has little effect. Timbers are sometimes preserved with high vapor pressure liquid fumigants such as chloropicrin and metham-sodium (VAPAM). There has been some experimentation treating large timbers by injecting the fumigant through holes bored into the wood. However, the gas tends to escape in an uncontrolled manner through checks and defects in the timber and continues to outgas after the treatment has been completed.

Chloropicrin is prohibited in California and these fumigants are generally very toxic. There may be some use for them in preserving the present spars.

Sodium borate (disodium octaborate tetrahydrate) is a highly water soluble wood preservative that is transported in wood by diffusion. Diffusion works best in wet wood. Diffusible preservatives travel much faster through end grain than side grain and generally move fairly easily through Douglas Fir. They have the disadvantage that they will leach away along the same paths if subjected to more water after they've been applied. Sodium borate was used to preserve *Mary Rose* and *Wasa* immediately after they were raised after centuries of being submerged when the wood was still wet. More recently, it was used to arrest the rot of the steam schooner *Wapama*, which was dry. There is no dry rot fungus which is highly resistant to it.

The wood toxicologists (Appendix II) who have been consulted about *C.A. Thayer* agree that the use of boron in some form is probably the only useful wood preservative in her situation. The borate treatment of *Wapama* was very intensive but the results of it are not really known since there was no proper baseline study of the extent of the rot done before the treatment started. In addition, *Wapama* had already dried out for years when the borate treatment was begun; consequently, she had to be subjected to months of intensive, periodic, regular wetting with borate saturated spray to get adequate penetration. The diffusion treatment does not work through dry wood as the treatment relies on a high percentage of free water in the wood. Consequently, a spray treatment of *C.A. Thayer* will be more effective since she is not as dry as *Wapama* was. The success of the diffusion treatment relies on accurate control of solution strength, protection against drying out and allowing adequate time for the process to occur. A wood

preservative is effective only when it reaches a certain concentration in the wood and it stays effective only so long as it remains at that concentration. However, any treatment of a structure like this is, by its nature, haphazard and the outcome is difficult to predict. Any successful spray treatment will unequivocally take months if not years. Partially decayed areas or spots likely to decay in large timbers can also be protected by inserting solid sodium borate rods. Sodium borate has the added advantages of being a fire retardant and protecting timbers from wood destroying insects. Timber treated with a water soluble, diffusible preservative must be kept dry after the preservative has reached the correct concentration, or more must be constantly added.

Sodium borate has a low toxicity for humans. It is an ingredient in laundry detergents and there have been no indications to date that it is dangerous. However, even if the borate treatment is confined to the inside of *Thayer*, a small amount will inevitably leach through the hull to the extent that it will be measurable in the water near the vessel. The amount and importance of it depend on the extent of the treatment. It is believed that the environmental impact will be small if proper care is exercised.

Some form of sodium borate treatment can be used effectively on *C.A. Thayer*. The dry rot can be arrested or slowed if the treatment is done well. However, it should be pointed out that wood that has been weakened or lost through decay is not renewed by the application of a wood preservative and the strength of a vessel is not increased following treatment.

■ Waterproofing the Deck

Fresh water transports the rot fungi and wets the wood so that the rot can grow. That water comes in mostly through the deck. Consequently, the most important thing that can be done to arrest the decay of a wooden vessel is to keep freshwater from leaking through the deck. *Thayer*'s deck has deteriorated through neglect to the extent that it can't be made perfectly watertight by simply being recaulked. Although the bottom of the decking and the top of the beams are rotted, the upper surface is generally hard enough to be caulked. A skilled hand working year round on the decks could do much to slow the leaks. Patiently recaulking the worst seams and replacing the poorest planks would do much good. Keeping a traditional laid deck watertight takes regular maintenance. To make this deck more water resistant, the NPS must anticipate that a certain amount of seams and planking will be repaired yearly. Scraping the seams flush with the deck will help them remain watertight and will discourage rot.

The worst seam on the deck is the joint between the waterway and the covering boards. So much water leaks through now that there are mold and fruiting fungus bodies underneath. It is likely that this seam will never be perfectly watertight. However, it can probably be repaired so that it will be much more water resistant. If the paint is stripped off this area, the rotten parts can be identified and removed. Because of the form of construction, the waterway timbers can probably be left intact. The extent of the repairs necessary can't be determined until the paint is stripped off this section. Although they are very deteriorated, they can still be much improved through daily maintenance and regular repairs.

There have been many suggestions that *Thayer* should be fitted with a cover to keep the rain out. A permanent cover will change the look of the vessel, consequently the idea of a temporary one that is re-erected every rainy season is generally preferred. Unfortunately, an unsupported awning is impractical because of the wind loads (Tri-Coastal Marine, 1987). Whether temporary or permanent, the cover would have to be relatively robust and well attached to the vessel. The present cover of *Wapama* gives the idea of the form and complexity of the structure. Assembling and disassembling a cover like that every year is not a minor task and it will significantly change the appearance of *Thayer* for at least five months every year.

An alternative method for keeping the water from going through the deck is to cover it with a new, permanent surface. Traditionally (since WWII), the lives of working wooden ships have been extended by covering the decks with asphaltic roofing material. This is an accepted method for working vessels and continues to be used on the East Coast and in the Gulf where it is known affectionately as "Miami teak." The deck is first smoothed, then roofing paper bedded down on asphaltic cement is tacked down to it. All of that is then sealed with roofing paint and several coats of normal exterior paint. A covering like this can be expected to keep the deck substantially watertight for years. It will significantly change the appearance of *Thayer* but not as much as a cover would. If the vessel is later preserved in a building, the "Miami teak" can be removed leaving the deck not much different in appearance than it is now. In the event *C.A. Thayer* is rebuilt, the present deck cannot be reused.

■ Strength of *C.A. Thayer*

Primarily due to the rotting of wood, the strength of *Thayer* has declined considerably from what it was in 1895. Nearly a hundred years of rot and decay have made her soft and have weakened the structure to the extent that

she cannot be sailed—that much is obvious. What is less apparent is that with every year she is less able to withstand the forces of merely floating in the Aquatic Park. The severe and increasing hog she suffers from is a sign that she is succumbing to these static loads. (A "hog" is the characteristic humped back shape seen on many old wooden ships. The center rises up and the ends droop down—like the profile of a hog.)

For a body at rest, the internal and external forces have to be in balance. The external loads are due to weight, hydrostatic pressure, waves, wind and mooring forces. The total load is the sum of the external loads. If there is an imbalance in the distribution of these external loads then there must be a compensating internal load to keep the body in equilibrium. The only steady forces acting on a floating ship are weight (always down) and the water pressure force (inward on the hull). Buoyancy is the vertical part of the water pressure force. For a ship to float, the total weight and buoyancy must be equal—that's Archimedes' Principle. If the distribution of the weight and buoyancy are equal and opposite, as for a floating log, then they cause no internal forces on the structure. However, the hydrostatic pressure force always causes internal forces (as in the sides of a ship where it is unopposed by a weight force). This pressure force is proportional to the water depth—it's large for a submarine, but small for a canoe.

The internal forces coming from the unequal distribution of weight and pressure try to bend the hull longitudinally (like bending a long thin beam), and to bend the shell of the ship. For a long, thin ship with interior bulkheads the stresses caused by the first phenomenon dominate (primary direct stresses). However, *C.A. Thayer* is relatively short, shallow and wide and has no bulkheads amidships; in her the second phenomenon is also quite important (secondary stresses). Unfortunately, there's no standard method for calculating these secondary stresses in a vessel like this with few transverse bulkheads and a rapidly changing bottom geometry.

Normal practice in a thin walled steel ship is to just add these stresses (which, primarily because she is not thin walled, is not wholly correct for *Thayer*). For a vessel suffering from hogging forces, the primary stress is tensile at the deck and compressive in the bottom. Within the bottom shell, which is being pushed up by the hydrostatic force, the secondary stress is compressive on the outside and in tension on the top. The combined stress is forcing *Thayer* to hog. An elastic structure deflects proportional to this stress and to the relative stiffness of the structure.

Stiffness comes from the shape of the structure and the

materials it's built from. Material properties can change. This is especially true in wood which gets softer as it gets wet and rots. Certain shapes are inherently stiffer. A board on edge is more resistant to bending than the same board laid flat. *Thayer* is wide and shallow more like the board laid flat. Manufactured beams have flanges and webs. When a long "I" beam is bent, the vertical web carries the shear force between the two horizontal flanges. For a hollow girder, like *C.A. Thayer* with no longitudinal bulkheads, the shear force is carried primarily in its sides. Along the centerline, the shear stress is zero.

Structures subjected to continuous steady loads change shape through creep in the materials and the small shifts of members relative to each other. The bending stresses on *C.A. Thayer* are actually very small and the consequent elastic deflection and material creep are small. In spite of that, she now has a large (14" vertical deflection) hog in the keel. The major component of this deflection is due to the incremental, non-elastic shifting of elements of the structure. (There isn't a word for this for ships, although the process is akin to the "settling" of buildings. Together with the material creep, it will be called "creep deformation" here.) It began in earnest when *Thayer* ceased carrying cargo. When a wooden vessel decays, it gets softer and this slow creep deformation speeds up. (It can rapidly accelerate as it did with *Wapama* in 1980. The hog started to increase so quickly that she could no longer be made watertight and there was fear she might break up. She was hauled out on a barge where she remains.) This creep deformation occurs mostly because of the inherent inability of a traditional wooden hull to carry sheer. In effect, the hull longitudinals slide over each other, allowing the vessel to hog. The principal mechanism that restricts this is friction between the planks in the hull and ceiling. That's why caulking is put in so tight and recaulking a vessel does so much to stiffen it. When the topside planking of a wooden ship dries, the caulking loosens and she loses much of her longitudinal stiffness.

A structure can be made more resistant to deflection, including the long term creep deformation, by either making it stiffer or reducing the stresses. There have been many suggestions about how to stabilize or reverse the hog in *C.A. Thayer* short of rebuilding her. These are all included in two main themes. The first is to reduce the internal forces by adding weight, buoyancy or a combination of the two. The second is to strengthen the vessel with added structure in the form of some sort of longitudinal girder.

■ Ballast and Buoyancy

MGA calculated the distribution of the weight and buoyancy for *Thayer* to determine the internal forces which are operating on her and to assess the practicality of potential remedies. The distribution of the vertical internal forces is usually expressed as a longitudinal bending moment. The bending moment at a point due to a force depends on the magnitude of the force and its distance from the point. Bending moment curves are indications of how much a beam will bend. A graph of the longitudinal bending moment for the vessel in its present state is included in Appendix III.

The addition of ballast is the least expensive way to correct the hogging forces. (Lead prices fluctuate between thirty and forty cents per pound.) The second loading curve (Appendix III) shows that the midship longitudinal bending moment can be made zero by adding approximately 225 long tons of ballast amidships. This is slightly over 700 cubic feet of lead or about 3600 cubic feet granite ballast. This may be acceptable, but the ballast will lower *Thayer* an additional twenty inches in the water. The planking immediately above the present waterline is very deteriorated and is presently not watertight. Repairs would have to be made to the planking before adding all this ballast. In addition, there is a real question as to whether the bottom can support this much weight.

The longitudinal bending moment can also be made zero by adding 125 long tons of ballast amidships and twenty-five tons of buoyancy at each end. This has the advantage of only immersing the vessel an additional five inches. Twenty-five tons of buoyancy is equivalent to 875 cubic feet of air—about the volume of a small bedroom. It should be apparent that added buoyancy is only effective if it is submerged. *C.A. Thayer* is presently moored at a site with strong surge and tidal currents. For these reasons any buoyancy chambers would have to be strongly built and well attached to the vessel with provision to sound and pump them out. Simple steel chambers, built in a shipyard, that would fulfill these criteria would cost about \$60,000 to fabricate. There are potential pitfalls associated with the addition of buoyancy chambers that could harm the vessel. Even if they are very carefully built and the buoyancy is slowly added, the chambers will bear unevenly on the hull. This could be a problem as could be the unknown effect of suddenly flooding a chamber.

To some extent, the progressive hogging of a vessel is self limiting. As the vessel humps up and the ends droop, the hogging forces diminish. Whether this occurs before *C.A. Thayer* breaks in two is problematical. However, if the forces can be diminished, failure is less likely. The bend-

ing moment can be reduced to about half of the present by adding 125 long tons of ballast. Slightly less than half of this in lead would fit under the present bilge boards. There remains the question about whether the bottom can support ballast. The only way this can be determined is by adding it in incremental amounts and checking the deflections.

■ Structural Reinforcement

In the past, there have been many suggestions that *C.A. Thayer* and vessels in a similar predicament should be strengthened to resist hogging by adding some kind of longitudinal girder or truss to their structures. As was stated previously, the bending stresses are very small, but they continue to cause creep deformation. If the vessel is to be prevented from suffering further hogging, the safest design is one where the added structure takes the entire bending load. A first approximation for a steel box girder sufficient to carry this load shows it would have to be five feet high and weigh about fifty tons. The fabrication alone would probably cost over \$200,000. A more refined design or the use of other materials might reduce the cost or the size somewhat, but it will remain large, heavy and expensive. If something like this were added inside the vessel, it would significantly change the character of the hold. If it were added to the bottom of the keel, *Thayer* would ground out in her present berth. It should also be mentioned that although installing some kind of new structural reinforcement like this has been suggested for other wooden ships, it has never been done. The local effects of adding a large, rigid reinforcement like this are not known and must be regarded as experimental.

Theoretically, the new structure would not have to carry the entire bending load as *Thayer* does have some strength—if she didn't, like a piece of cooked spaghetti, she would immediately fold in half. Determining how much strength she does have is the problem. Much less new structure would have to be added if it could be effectively added to the existing structure. If this course of action is selected, some experiments need to be conducted to the ship in order to determine the approximate strength of the hull. The design of this new auxiliary structure would need to take into account further deterioration of the wood in the future.

The Historic Structure Report (HSR) recommended that the lowest stave of bilge ceiling be removed to increase air circulation in the frame bays and to allow inspection of the lower keelsons, keel and floor timbers. The *C.A. Thayer* Preservation Committee agreed with this although there were some reservations about the loss in strength. If

Thayer were a homogeneous beam (if there were no shearing of the longitudinales) then the loss of longitudinal strength would be slightly less than one per cent. Since the longitudinales do slip past each other, the actual strength loss is less. There would be no effective loss of transverse strength.

The void under the fisherman's forecastle is rotten to the extent that large chunks of ceiling plank and frames have disintegrated and the hull planking is visible. There is putrefying water in the frame bays and the area continues to decay rapidly in the dank atmosphere. It is presently "out of sight out of mind"—it appears to be rarely visited by maintenance personnel. Ventilation and inspection of this area need to be increased. It was suggested in the HSR that the forecastle bulkhead be removed beneath the line of the forecastle sole and that there should be some forced ventilation to dry this area out to slow the decay.

■ Recommendations for Short Term Preservation

All of these recommendations should be implemented immediately. They can all be done without dry docking *C.A. Thayer* or removing her from service for extended periods. The deterioration of the vessel is due to many interrelated effects and, although implementing any one of these recommendations will help, it is preferred that they all be done. Some of these items are covered at length in the HSR. They are repeated here to emphasize their importance.

- Cease all fresh water washing of the deck immediately. If salt water is not available, do not wash the deck.
- Begin treatment with sodium borate solution. The NPS has all the material, equipment and manpower necessary to begin preserving the wood of *C.A. Thayer* now. Additional costs will be very small. Since she is moored in the Aquatic Park and any extensive runoff would probably cause public concern, the main treatment should be less extensive than that of *Wapama* and confined to the interior of the vessel. During the treatment, *Thayer* will remain open to the public above deck.

The principal object of this treatment is to arrest the further decay of the lower framing, floor timbers and centerline timbers. The conservation of the deck, the hull above the waterline and the deck structures is of secondary importance. The deck is so decayed that no part of it can be used in a future reconstruction. The cabin and deck house are somewhat decayed, but they are not important to the survival of the vessel. The deck and superstructure are very dry and any treatment with

a diffusible preservative relies on the surfaces being kept wet. However, localized treatment of visibly rotted areas may have some use. Extensive treatment of the deck would require removing *C.A. Thayer* from service. The consequent runoff would probably be unacceptable.

- The entire interior of *Thayer* should basically be soaked with borate solution. A PVC pipe spray should be rigged adjacent to the air stake in the ceiling so that it sprays into the frame bays several times a day. A single pipe should deliver a spray to the top of the bottom longitudinals. The sprays should be applied frequently enough so that all the surfaces in the interior of the hold are always saturated allowing the chemical to diffuse into the wood. Portable sprayers should be used on a daily basis to saturate the surfaces of the stem and stern framing and any surface not reached by the spray installation. The area around the frame heads beneath the covering board should receive special attention.

The sodium borate saturated water will collect in the bilge and will diffuse into the floor timbers, lower futtocks and keel. This effluent can simply be filtered and reused. Periodically it may be necessary to empty the bilge, in which case it can be pumped out with a portable pump and disposed of properly. Sodium borate is an ingredient of some laundry detergents and is non-toxic to humans. The treatment will continue until test boring indicates that the chemical has reached satisfactory levels in the wood. In no case should the treatment be ended in the rainy season.

- Repair the deck. Strip the paint from the waterways and covering board and assess the extent of the rot there. Repair the rotten areas. Scrape the deck. Identify the worst seams and deck planks and repair them. Begin a program of daily and regular maintenance designed to make the deck watertight.
- Remove the lowest stave of bilge ceiling port and starboard. Clean and examine this area. Clean the limber holes. The practicality and cost of rebuilding *C.A. Thayer* depend on the condition of the centerline structure and lower framing which is largely unknown. The type of floor timbers and the location of joints in the centerline timbers can be discovered once this piece is removed. Also, its removal will aid the drying of the frame bays once the borate treatment is completed. The ventilation, cleaning and inspection of all parts of the interior should be increased. The bottom of the forecastle bulkhead should be removed as outlined in the HSR.
- There must be increased routine maintenance of the hull above the waterline. More effort should be spent on the inspection and repair of topside hull planks and

seams. The entire topside of the vessel must be painted yearly. This work must precede any ballast addition.

- Add ballast to decrease the bending moment. One hundred and twenty-five long tons of ballast centered at frame #32 should be added in the hold of *C.A. Thayer*. The ballast will be distributed approximately uniformly over forty feet of the bottom. About fifty tons can be stored underneath the present bilge boards. Ability of the vessel to support this ballast is presently unknown and it should be added incrementally. The effect of adding the first ten tons should be measured by an engineer. These measurements will be used to calculate an approximate strength of the hull "girder" and as an indicator of the local strength.

□ Long Term Preservation

C.A. Thayer has National Historic Status. By law, the National Park Service must preserve it forever. No one will argue about the meaning of the word forever, but there is a continuous and spirited debate about what is meant by preservation. There is a world of well held positions in the debate; however, the argument is plainly shown by two held by pure preservationists at the polar extremes. The first demands the preservation of the historic fabric. Essentially, the vessel would be preserved as a relic. The wood itself is preserved much as one saves fragments of the true cross. A problem with this is that *Thayer* has been changed and repaired many times in the past. All parts do not have the same historical significance.

At the other extreme, the form and function of the ship must be preserved—the wood alone is meaningless. From this viewpoint, the ship should be rebuilt and sailed in the same way she was in 1895. The methods of building and sailing a wooden ship is viewed as being more important than the preservation of the vessel itself. The ideal of this type of restoration is that *C.A. Thayer* remain a ship in the water. If she needs to be rebuilt one hundred years from now, her construction will be like the original and will guide the future generation. A structure which is heavily modified or patched together will tell them little about the original construction method.

Thayer can't be preserved as a floating exhibit indefinitely without rebuilding her. Based on previous surveys, most of the hull and deck are rotten. So much strength has been lost due to this deterioration that the hull is unable to withstand the static forces that are on it in the Aquatic Park. Even if the rot is completely stopped, that strength won't be restored. To remain afloat, a majority of her significant, historical structure must be rebuilt in some fashion. "Full restoration" implies the complete rebuild-

ing of *C.A. Thayer* by replacing all damaged parts with identical new material with the intention that the original strength and appearance of the vessel be restored.

Full restoration with in kind replacement of damaged material is the traditional method of restoring old wooden vessels. The biggest plus to this method is that it would return *Thayer* to her original appearance and strength, with the great appeal of permitting the vessel to sail once again. *Thayer* can be restored to exactly the same condition as she was when she was built by H. D. Bendixsen almost 100 years ago. If the new wood is treated with wood preservatives and the vessel is properly ballasted to reduce bending stresses, the vessel can be preserved for the next hundred years with regular maintenance. However, it should be clear that the maintenance required to keep the renewed vessel healthy is substantially greater than what she receives now.

There are several large wooden vessels in the U.S. that have been restored with extensive rebuilding. The oldest and best documented of these is *USS Constitution*. She was built in 1797 and had major rebuilds in 1833, 1874 and 1927. Very little of her original structure remains. Rather like *C.A. Thayer*, these restorations have been in reaction to a shocking deterioration in the vessel. Since her last drydocking in 1973, the *Constitution* has had a dedicated maintenance facility and consequently has decayed very little since then from rot. Her keel was completely straightened in the 1927-31 rebuild but she began to hog rapidly when relaunched. Because of the recent high level of maintenance, the hog has increased very little since the last drydocking. Another major reconstruction is planned in advance of the 200th anniversary of the vessel in 1997. The plans are to straighten the vessel and incorporate new, reinforced plastic structure that will carry the entire bending load and prevent future hog deformation. The rebuilding will mostly be done by an independent contractor in *USS Constitution*'s drydock facility.

The current state of *Constitution* is very different from *C.A. Thayer*. First of all, *Constitution* has very little rotten material. Secondly, although both vessels have about fifteen inches of hog in their keels, *Constitution* is a much bigger ship and the magnitude of the forces causing her to hog are only half of those of *Thayer*. The proposed new structure for *Constitution* is quite elaborate, but is completely beneath the orlop deck—hidden from public view. In addition, it has been designed to resemble structure that was in the vessel before the last rebuild. A similar structure is really not feasible for *C.A. Thayer*.

Mystic Seaport Museum has done complete restorations on several large wooden vessels. The standard of mainte-

nance there is excellent and the wood in these vessels has decayed very little since the restorations. In spite of this good maintenance, these vessels have all suffered to some degree from structural creep deformation. The Museum has its own dedicated repair facility, lift dock and work force.

The North End Shipyard in Rockland, Maine, specializes in this type of restoration and has completely rebuilt several passenger carrying "dude" schooners. Commonly, they haul the vessel at the end of their sailing season, dismantle and rebuild it almost entirely, and launch it before the next season begins. Their facility is simple and very much like a nineteenth century shipyard. Many of the workers who have trained at the North End Shipyard are now independent contractors.

Evidently, full restoration is a feasible alternative. Wood and the other necessary materials are available. Douglas Fir is not as cheap or as plentiful as it was in 1895, but it is possible to get the long lengths and quality of timber comparable to the original. The expertise to rebuild the vessel also exists. There's been a small renaissance of wooden ship building in the last fifteen years in this country. Groups of professional builders travel around the country building historic replicas and rebuilding old wooden ships (Appendix II). There are local firms that are fully capable of doing this restoration. The procedure for the full restoration is detailed in the HSR.

Once the decision to fully restore *Thayer* is made, the timber should be bought at once, brought to the building site and properly stored. The wood should be treated with a preservative prior to storage. Sodium borate seems to be the most promising and the least expensive. Although *C.A. Thayer* probably wasn't built with perfectly dry wood, her deck and topside were often wet, and she mostly stayed in a colder and moister climate. Sitting at the dock in San Francisco Bay, that wood just gets drier and drier. Consequently, it's very important that the deck and topside hull planking be air dried to a moisture content of ten per cent or less before installation. Otherwise, when this wood dries, it shrinks—that opens up the seams which lets in rain water and causes rot. Also, when the caulking loosens in the topside planking, the ability of the hull to resist bending is decreased. All the above waterline timbers should be purchased far enough in advance to insure they have the proper low moisture content when they are installed.

The sequence that should be followed during the restoration is not exactly that outlined in the HSR. It's true that the extent of the rebuild and the exact schedule can't be determined until the vessel is partially disassembled and

the rot in the centerline timbers is assessed. However, based on previous ships that were not as rotten as *C.A. Thayer* and were completely rebuilt, very little of her can be saved. The amount of retained historic fabric will depend greatly on its condition and the amount of effort (and money) the NPS is willing to invest. It would be very misguided to try and save her existing shape, as it is severely distorted. After the vessel is hauled it should be dismantled entirely until only sound wood remains. Then she will be rebuilt using new wood to a fair set of lines that is the best representation of the vessel when she was new in 1895.

The essential requirements for the restoration facility are given in the HSR. That report mentioned the ideal nature of the smallest drydock in the Hunter's Point Naval Shipyard as a repair facility. It has all the tools and buildings necessary to do this job. The Preservation Committee thought the same and strongly recommended that the NPS get the use of it for repair of all the large vessels in the collection.

Typically, these wooden ships were built by robust men in very modest facilities. *C.A. Thayer* can be rebuilt at a site that is far less well equipped than the Hunter's Point Drydock is. The HSR mentions the possibility of rebuilding the vessel on a barge alongside the Hyde Street Pier, which would let the public see the work as it's done. This is feasible, although working on a barge or a floating drydock complicates the process by adding the difficulty of transferring material from land to the floating facility. In addition, the rebuilding process will generate tons of wood chips and dust which will be a problem in the Aquatic Park. Actually, the most efficient site would be on solid ground that's on the same level as the machinery and wood storage. She could be hauled on a marine railway for a major rebuilding like this, although there are no railways big enough left in the San Francisco Bay. In any case, it's made clear in the HSR that the costs associated with setting up a suitable facility will only be a small fraction of the total restoration cost.

A reconstruction that restores *C.A. Thayer* to the identical condition she was in 1895 does nothing to address the forces which have caused her to hog over the last ninety-six years. As was previously mentioned, she can be ballasted so that the internal forces that cause the bending are reduced. Ballasting is more attractive for the renewed vessel since she can be expected to withstand the local ballast loads and the new topside hull planking will be watertight. Although Bendixsen was an expert builder and *Thayer* was constructed from the best Douglas Fir, she was not rationally designed from a structural perspective. At the time, steel was relatively expensive and wood was

cheap. The long lengths of the timbers in her clamp and deck did quite a bit to preserve her shape over the decades. However, many of her timbers were not arranged in a way that achieved the best affect.

There are many misconceptions about the structure of ships. One idea that has persisted is the importance of the "backbone" in stiffening a vessel. Wooden ships hogged principally because of the inability of the sides of the ship to carry the shear forces which arises from the primary stresses. Typical turn-of-the-century West Coast wooden ships had huge keel/keelson backbones which actually did little for longitudinal strength because the shear stress is nearly zero there in a homogeneous beam. To be truly effective, a keel assembly like this would have to be much stronger in both shear and bending and would have to carry the entire bending load. That means it would have to be built out of metal or some other strong material.

If the vessel is rebuilt, it makes sense from an engineering point of view to incorporate some high strength material into the structure to minimize any future creep deformation. Any added structure will have to be extensive to be effective. Probably the only structure that could be completely hidden is diagonal metal strapping in the hull between the frames and hull planking. This method was a traditional 19th century wooden shipbuilding technique. Adding any new material, even if hidden in the existing structure, may be unacceptable to strict preservationists.

A disadvantage of total reconstruction is that much of the patina of age will be lost. There has been discussion of the uniqueness of the cargo hold and the importance of retaining the ceiling planks. Indeed, the condition of the ceiling appears to be good in the cargo hold, but that belies the actual state of decay. The HSR illustrates how the surfaces of the ceiling planks could be laminated to new timber. However, due to the decay of the timbers and the fact that they were fastened and edge bolted with steel makes it very unlikely that these planks can be removed in one piece. If the NPS feels that preserving historical fabric with such techniques is necessary, the restoration cost will rise significantly. Traditionally in wooden ship building, it has been considered bad practice to repair a piece of wood that had more than a small amount of rot in it. If a timber was partly decayed, it was removed entirely and replaced with a new one. Based on the survey results from the HSR, most of the timber in the vessel must be renewed.

Another drawback to complete restoration is the cost. The HSR estimated the cost of rebuilding *C.A. Thayer*'s hull and deck to be about six million dollars. This figure is based on most of the work being done by an independent contractor in a dock belonging to or controlled by the

NPS. (However, it doesn't include the costs of that facility.) If the rebuilding is done in a commercial yard or by civil service employees of the NPS, the costs will be higher.

It's been stated that the scope and cost of the rebuilding can't be determined until *C.A. Thayer* is partially disassembled. At a certain point, costs rise in proportion to the amount of the vessel that is saved. Indeed, for a severely rotten ship like *Thayer*, it's usually cheaper and gives better results if an entirely new vessel is simply built on the keel of the old vessel. That's owing to the relative difficulty of fitting new pieces to old.

The fastest and most efficient method of rebuilding *C.A. Thayer* is to do it in a single stage at a suitable facility. Then she can be dismantled enough so that the hog can be removed entirely from the keel and the hull can be returned to its original shape. It has been suggested that the hull and deck be rebuilt in stages to spread the costs over a longer period. This process is very much more difficult than new building, generally takes more fitting and requires the use of shorter pieces of timber. This piecemeal approach is discussed at length in the HSR, which states that the result would be weaker and generally inferior to the single step approach. This method will build the hog deformation into the vessel. An even worse job inevitably results from attempting to rebuild major parts of a vessel while it is afloat. Hogging forces become unrestrained when the deck and topside hull structure are removed. Hog and structural deformation in general are inevitably increased during this process. Rebuilding a vessel while it is floating has been attempted many times in the past, but never with a good result. *Thayer* is so decayed and weak that the vessel may not survive the attempt to rebuild her in this fashion.

The complete restoration is not the kind of task that can be accomplished by simply handing it over to a commercial yard. There is no existing shipyard in San Francisco Bay that has the knowledge or the ability to rebuild *C.A. Thayer*. It's been suggested that the NPS acquire its own repair facility to maintain its fleet of vessels. The HSR cost estimate is predicated on the work being mostly done by an independent (non shipyard) contractor in such a facility. This approach will result in the best job at the lowest cost.

Alternatives to Full Restoration

As was previously stated, the NPS is bound by law to preserve *C.A. Thayer* forever. Undoubtedly, the best way to preserve the existing fabric of the vessel is to haul her ashore and preserve her in a building. This has been done

with varying degrees of success to several large wooden vessels in the past.

Wasa is a 1400 ton Swedish warship that sank on her maiden voyage in 1628. She laid undisturbed in the cold waters of Stockholm harbor for almost 350 years until she was raised in 1962. At 110 feet, the water pressure is about fifty p.s.i.—a pressure far greater than that used for commercial wood preservative pressure treatments. The water penetrated her oak timbers completely and caused the cells in the wood to swell and rupture. Because of the low temperature, the salt, the lack of oxygen and the dearth of ship worms in Stockholm harbor, her timbers are essentially undecayed. When she was raised, the principal problem was to introduce a substance into the wood that would replace the water as the wood dried. If this isn't done, the wood rapidly "debulks" where it dries in a non uniform manner causing it to change shape, split and even disintegrate. As soon as she was taken out of the water she was moved to a climate controlled building where the air pressure was kept slightly above atmospheric. She was constantly sprayed with a solution of polyethylene-glycol (to replace the lost intra-cellular water) and sodium borate (wood preservative). The actual preservation process took over twenty years—far longer than was originally planned. Today, the *Wasa* is in nearly original condition. She is the number one tourist attraction in Sweden. Last year she had five million visitors. Her preservation and restoration have been a complete success.

In contrast with *Wasa*, which is nearly completely restored, *Mary Rose* is merely a relic. *Mary Rose* is a Tudor warship (a 700 ton carrack) that sank in 1545 when she was thirty-five years old. Only a fragment of her hull remained when she was raised in 1982. The hull fragment was so fragile that it had to be lifted on an elaborate frame. She rests today on that frame in a climate controlled, covered drydock. The timbers remain delicate and are sprayed with chilled water most of the day. Her timbers were also preserved with polyethylene-glycol and sodium borate.

The polar ship *Fram* was built in 1892 for the Norwegian explorer Nansen's attempt to drift with the pack ice to the North Pole. This is an extremely famous vessel and is regarded as a monument in Norway. *Fram* is 128' long, 36' of beam and displaced 800 tons when afloat. She is approximately the same size and age as *C.A. Thayer*, but far more heavily built and having a much stronger structure. After she retired from polar exploration in 1914, she returned to Norway and was derigged and neglected for ten years. In 1925 her former captain began efforts to preserve her and in 1934, following his death, she was removed from the water and a glazed building was erected

over the rerigged ship. She has received good maintenance since then and is well preserved.

Like *Fram*, *St. Roch* was very strongly constructed for polar exploration and navigation in the ice. She was built for the Royal Canadian Mounted Police in 1928 and was famous for two voyages through the Northwest Passage. She is 104' long and weighs 232 tons. She retired from the RCMP in 1954 and was purchased by the City of Vancouver, B.C. She was permanently drydocked in 1958 and enclosed in a building in 1966. Although she was in good condition when she was drydocked, the timber was never properly preserved. In addition, the moisture and temperature in her building fluctuates which allows her to slowly decay. She is presently awaiting a major restoration.

Basically, all these vessels represent preservation successes. However, they are substantially different, both in type and condition, from *C.A. Thayer*. The vessel in the closest condition to her at the time she was hauled is the coasting schooner *Australia* at Mystic Seaport. She was removed from the water in the early 1960s to be repaired as she was leaking badly. She was partially disassembled with the idea of restoring her but the idea was abandoned. She remained out of the water and began to rot rapidly as she dried. Now all that remains is a relic which is housed in a corrugated steel building with a dirt floor which is open to the atmosphere. Visitors can walk through her and see how wooden ships are built. She is not being preserved beyond keeping her inside. She continues to deteriorate although at a slow rate.

There are no major engineering problems associated with putting *C.A. Thayer* in a permanent berth ashore. Essentially, the process is to drydock her atop a flooded barge, then pump out the barge and refloat the *Thayer*/barge combination. A steel cradle is assembled around the vessel, strong enough to support her when she is skidded off the barge. The barge is then moved near the permanent site where the vessel, supported by the cradle, is slid off onto land. Considering the cost and feasibility alone, the ideal site is one where the barge grounds out so that the bottom of the cradle is level with the skidway. It is possible, but far more difficult, to do a move like this from a floating barge. (Generally, piers are not suitable for this type of operation or supporting this much weight.) If the site is such that the barge can't approach it (the Presidio Army Base has been suggested), the move would have to be preceded by extensive earth moving and dredging. There are a very few huge cranes in the world, used in offshore engineering, that could conceivably be used, but that again depends on the site. Their daily cost is very high. Once the vessel is on its site, the building is erected over it. The cost of a move can only be estimated when the site

is identified. Whatever its nature, a move like this will be an expensive and complicated operation. It is also unlikely that a site of any sort can be found next to the NHP.

As far as the ability of *Thayer* to withstand a move to a permanent site on land, it can be managed so that the loads on her will be like those involved in a simple drydocking. That is, a move can be engineered that will cause anxiety, but no structural damage. As she gets more rotten, she will get progressively weaker and less able to withstand the move. Consequently, the supporting cradle will have to be more robust and elaborate.

One of the dangers of moving *C.A. Thayer* ashore is that she may deteriorate even more rapidly. Putting a wooden ship in a dry berth is not a panacea and the end of all maintenance. People have pointed with alarm to the cases of *Wapama* and *Charles F. Gordon* both of which deteriorated rapidly after being hauled out due to an acceleration of dry rot and structural changes in the wood due to rapid drying. It's been shown that both of these phenomena can be managed by saturating the timbers with a sodium borate wood preservative and then controlling the rate of drying over an extended period. It's critical to keep the vessel wet after it is hauled until the wood preservation treatment is completed. The use of polyethylene-glycol or some other agent to replace the lost moisture will probably not be necessary to preserve the *Thayer*. This is the expected preservation sequence:

1. Move *C.A. Thayer* to its permanent site. Immediately begin the sodium borate treatment.
2. Erect a permanent building over the vessel. The vessel must be protected from drying excessively while the building is completed.
3. Continue the intensive sodium borate treatment until adequate concentrations have been reached. This process will take years. The vessel will remain closed to the public during this time.
4. Allow the vessel to dry slowly while monitoring any structural changes in the wood.
5. Open the vessel to the public.

It is true that a wooden ship that is merely hauled out on dry land without being preserved, as many ships have been, will deteriorate at a much more rapid rate than if it were left in the water. After the preservation treatment has been completed and *C.A. Thayer* has dried, her rate of decay will be much slower and she will no longer require the annual maintenance required by a floating ship. However, while the maintenance needs will be reduced, they will not disappear.

There have been many suggestions to restore or rebuild *Thayer* with plastics. One is to rebuild wooden structural members with epoxy resins or a combination of epoxy and wood. For example, the HSR shows how the rotten centers of deck beams could be rebuilt by graving in wooden filler pieces—this method does nothing to address the repair of the beam ends which are very rotten. Plainly the deck beams must be removed from the vessel to repair the hull, but because they are fastened to the clamp with steel drifts, it is unlikely that they can be removed in one piece. Conceivably, new beam ends could be patched on to the repaired beam middles and returned to the renewed vessel, but the repair would be weak.

Possibly some selected timbers, like hanging knees, could be repaired without extensive work. However, most could not be and would need to be replaced with new timber. The total reconstruction would be piecemeal. Repairs of this nature will undoubtedly show and will not preserve the original patina of the cargo hold. It will take longer and cost more than simply scrapping the piece. The result will be inferior both structurally and aesthetically.

One of the more marginal repair ideas is to saturate rotten timbers with epoxy resin. In essence, a thin epoxy resin is applied to the outside of decayed timbers in the hope that it will percolate through the wood before it hardens. The theory is that it will consolidate the rotten wood and fuse it with the good. Many wooden boat owners have repaired small pieces of wood with a popular product called “Git Rot” at least to the extent that the wood seems more solid. However, research has shown that partially rotted timbers that have been saturated with epoxy have large localized stresses when exposed to moisture due to the different rates of expansion of the two materials. This method has never been used with success on large timbers and is certainly not useful for something like *Thayer* with so much hidden structure. Even if the resin could be made to go everywhere in the wood before it hardens, it will do little to restore the longitudinal strength of *Thayer*.

Fiber reinforced plastics (FRP) have revolutionized boatbuilding since the late 1950s. In addition to new construction, it's been used with mixed success to repair old wooden boats. It's been suggested that the bottom of *C.A. Thayer* be sheathed with FRP. Such a sheathing would provide a watertight skin that would stop the entry of torpedos and the leaching out of borates. It will not add any significant strength and should not be considered as an alternative to rebuilding/replacing weakened structure.

Applying FRP above the waterline would be a mistake. In wooden hulls, water vapor is constantly passing out through the topside planking. An FRP layer will trap this

moisture against the wood and promote rot that will be very difficult to detect. Repairs would be impossible without removing the FRP.

The application of FRP to wooden hulls has a long troubled history. Modern adhesives and techniques should improve on the chances of success. However, FRP has never been applied to a vessel of this size.

■ Recommendations for Long Term Preservation

C.A. Thayer should be preserved in the long term either through complete restoration or through controlled preservation in a building ashore. Alternative methods which make extensive use of epoxy resins and reinforced plastics are experimental and should not be used. In the event *C.A. Thayer* is rebuilt, most of the timber will need to be replaced with new. Long lengths of Douglas Fir comparable to the quality of the original can be acquired through special arrangements with the sawmills. Before the wood can be ordered, the NPS, with the help of engineers, must decide on the lengths and grade of wood that will be used. After these decisions about her restoration are made, the wood must be purchased immediately to allow it to dry properly. Before being shaped and installed, the timbers should be preserved from decay and insect attack with a wood preservative. Additional high strength material may be incorporated with and hidden in the restored structure to minimize future structural deformation. The renewed vessel should be ballasted to reduce internal bending forces. In addition, the only suitable way to do a job of this magnitude is all at once, with no interruptions and with a dedicated work force. Following her rebuilding, *C.A. Thayer* must have an explicit plan for upkeep and a person responsible for her condition.

C.A. Thayer can be preserved out of the water. Although, her condition is different from other large vessels that have been successfully preserved ashore. The knowledge and techniques to insure preservation exist and have been proven. However, she should not be removed from the water unless the NPS is prepared for the entire preservation process. Removing *Thayer* from the water, installing her in her permanent site and preserving her in a building is a major undertaking. Even if the wood preservative treatment were begun when the vessel was afloat, it must continue after the vessel is hauled. The temperature and humidity of the building must be controlled while her wooden structure is preserved and stabilized. This process can be expected to take several years. After this phase is completed, maintenance of the vessel will be minimal. Attempting to store the vessel out of the water without

immediately moving her to a permanent site and preserving her is a recipe for failure. Preservation should proceed immediately upon removing the vessel from the water.

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■ Excerpt From List Of Classified Structures (LCS) Report

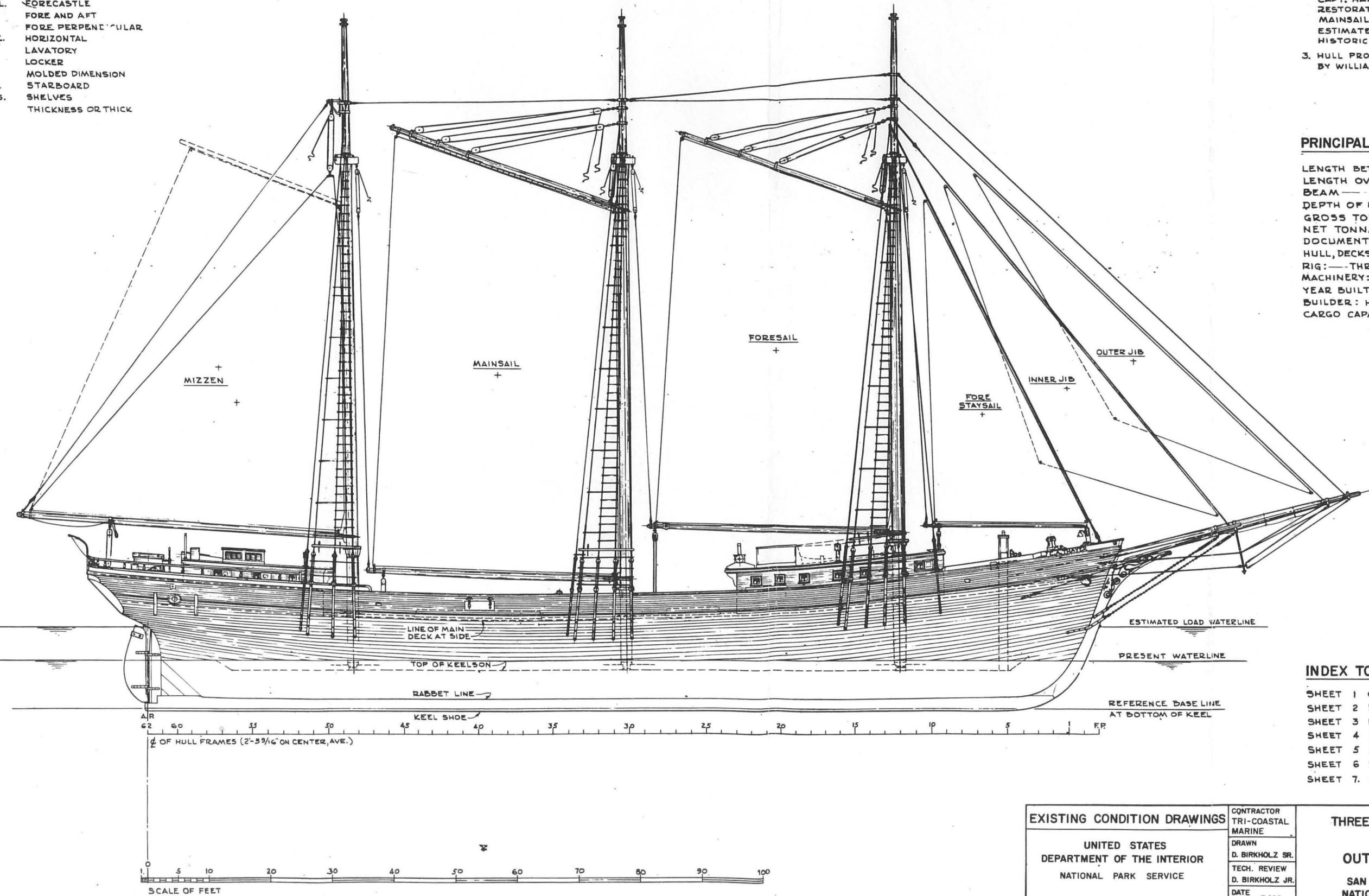
PARK/REGION REPORT

STRC NUM	IDLCS	NAME: RAILROAD REMAINS (SUTRO HEIGHTS)	PERIOD: HISTORIC
SH-23	05993	N.R.: UNDETERMINED NR STATUS	SIGNIF.:
		TYPE: RAIL RELATED	CUR. USE: TYPE VCZZ*****
		MCAT: C MAY BE PRESERVED	MGT. AGREE: NO MGMT AGREEMENT
		DATE: - CODE: 030181	DESIGNER:
		COND:	IMPACTS:
		LEGL: FEE SIMPLE	LEVEL OF EST: SIM. FACULTY
		TRMT: STABILIZATION NPS RESPONSIBILITY	APPROV.ULT. TRMT: PRESERVATION
		CYCLIC MAINT. NPS RESPONSIBILITY	INTERIM COST: 0 1/76
		ROUTINE MAINT. NPS RESPONSIBILITY	APPROV. TRMT. COST: 0 1/76
		APPROV.ULT. TRMT. NPS RESPONSIBILITY	APPROV. DOC: GMP
		DOC: DOCU	NAT. CAT: CRBIB: HSAR
		QTRS: BRIDGE: HAER:	NR REFNUM: HSPG HSR
		HABS:	
		TEXT:	
SH-24	05994	NAME: SUTRO HEIGHTS	PERIOD: HISTORIC
		N.R.: UNDETERMINED NR STATUS	SIGNIF.:
		TYPE: TYPE 15*****	CUR. USE: TYPE VCZZ*****
		MCAT: A MUST BE PRESERVED	MGT. AGREE: NO MGMT AGREEMENT
		DATE: - CODE: 030181	DESIGNER:
		COND:	IMPACTS:
		LEGL: FEE SIMPLE	LEVEL OF EST: SIM. FACULTY
		TRMT: STABILIZATION NPS RESPONSIBILITY	APPROV.ULT. TRMT: RESTORATION
		CYCLIC MAINT. NPS RESPONSIBILITY	INTERIM COST: 0 1/76
		ROUTINE MAINT. NPS RESPONSIBILITY	APPROV. TRMT. COST: 0 1/76
		APPROV.ULT. TRMT. NPS RESPONSIBILITY	APPROV. DOC: GMP
		DOC: DOCU	NAT. CAT: CRBIB: HSAR
		QTRS: BRIDGE: HAER:	NR REFNUM: HSPG HSR
		HABS:	
		TEXT: 20 ACRES OF GROUNDS	
SS-01	12951	NAME: THE C. A. THAYER	PERIOD: HISTORIC
		N.R.: ENTERED - DOCUMENTED	SIGNIF.: NATIONAL
		TYPE: VESSEL	CUR. USE: NPS EXHIBIT
		MCAT: A MUST BE PRESERVED	MGT. AGREE: NO MGMT AGREEMENT
		DATE: - CODE: 030181	DESIGNER:
		COND: POOR	IMPACTS: S WEATHER
		LEGL: FEE SIMPLE	LEVEL OF EST: SIM. FACULTY
		TRMT: STABILIZATION NPS RESPONSIBILITY	APPROV.ULT. TRMT: PRESERVATION
		CYCLIC MAINT. NPS RESPONSIBILITY	INTERIM COST: 0 1/78
		ROUTINE MAINT. NPS RESPONSIBILITY	APPROV. TRMT. COST: 87000 1/78
		APPROV.ULT. TRMT. NPS RESPONSIBILITY	APPROV. DOC: GMP
		DOC: DOCU	NAT. CAT: CRBIB: HSAR
		QTRS: BRIDGE: HAER:	NR REFNUM: 66000229 HSPG HSR
		HABS:	
		TEXT: 1895-3 MASTED SCHOONER; ROT IN MIZZEN MAST	

ABBREVIATIONS & SYMBOLS

A.P.	AFT PERPENDICULAR	PL.	PLATE
ABT.	ABOUT (APPROXIMATE)	P/S	PORT AND STARBOARD
APPROX.	APPROXIMATE	T&G	TONGUE AND GROOVE SHEATHING
AVE.	AVERAGE	W.C.	WATER CLOSET
CAB.	CABINET		
C.L.	CENTERLINE		
DIA.	DIAMETER		
FOCSL.	FORECASTLE		
F/A	FORE AND AFT		
F.P.	FORE PERPENDICULAR		
HORIZ.	HORIZONTAL		
LAV.	LAVATORY		
LKR.	LOCKER		
MLD.	MOLDED DIMENSION		
STBD.	STARBOARD		
SHLV.	SHelves		
THK.	THICKNESS OR THICK		

WOOD: CROSS SECTION — 
 LONGITUDINAL SECTION — 
 UNDEFINED STRUCTURE — 



GENERAL NOTES

1. THE PRESENT RIG IS A RECONSTRUCTION OF C.A. THAYER'S ORIGINAL RIG, WITH THE EXCEPTION OF THE JIB-HEADED MIZZEN WHICH WAS CARRIED DURING THE VESSEL'S LAST FOUR VOYAGES AS A CODFISHERMAN.
2. DIMENSIONS OF FORESAIL, MIZZEN, AND HEAD SAILS ARE BASED ON DOCUMENTATION FROM CAPT. HAROLD HUYCKE, DIRECTOR OF THE 1957 RESTORATION IN SEATTLE. DIMENSION OF MAINSAIL AND THE JIB-HEADED MIZZEN ARE ESTIMATED BASED ON SPAR LENGTHS AND HISTORIC PHOTOGRAPHS.
3. HULL PROFILE IS TAKEN FROM LINES DEVELOPED BY WILLIAM DOLL, SFMNH.

PRINCIPAL CHARACTERISTICS

LENGTH BETWEEN PERPENDICULARS	156'-0"
LENGTH OVERALL (HULL)	168'-6"
BEAM	36'-4"
DEPTH OF HOLD	11'-8"
GROSS TONNAGE	452
NET TONNAGE	391
DOCUMENTATION NUMBER	127097
HULL, DECKS, AND SPARS	DOUGLAS FIR
RIG	THREE-MASTED BALD-HEADED SCHOONER.
MACHINERY	STEAM DONKEY ENGINE IN DECK HOUSE
YEAR BUILT	1895
BUILDER	HANS BENDIXSEN, FAIRHAVEN, CALIFORNIA.
CARGO CAPACITY	575,000 BOARD FEET OF LUMBER.

INDEX TO DRAWINGS

- SHEET 1 OUTBOARD PROFILE
- SHEET 2 PLAN OF DECKS
- SHEET 3 HOLD ARRANGEMENT
- SHEET 4 INBOARD PROFILE
- SHEET 5 MIDSHIP SECTION
- SHEET 6 PIPING SYSTEM
- SHEET 7 ELECTRICAL SYSTEM

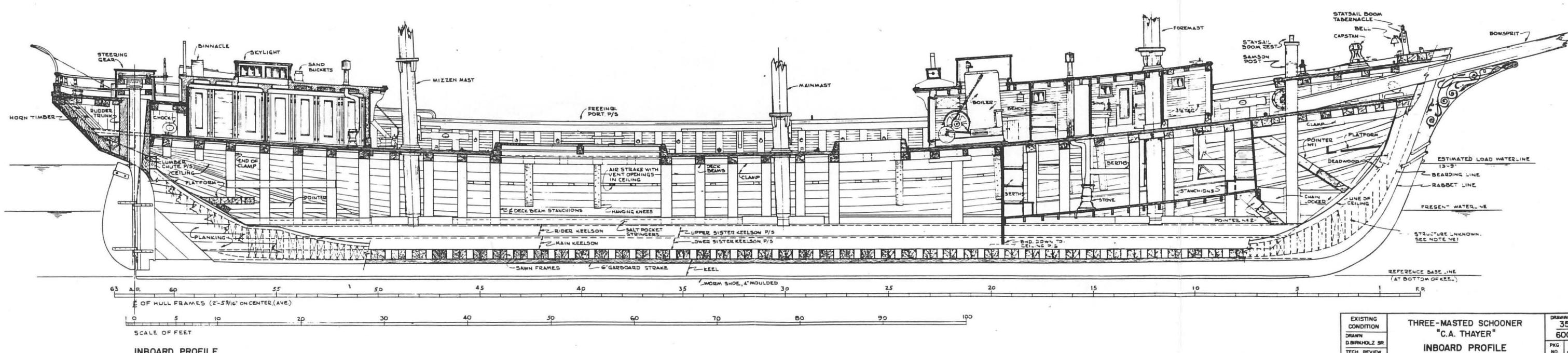
EXISTING CONDITION DRAWINGS	
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DEPARTMENT OF THE INTERIOR	TRI-COASTAL
NATIONAL PARK SERVICE	MARINE
	DRAWN
	D. BIRKHOLZ SR.
	TECH. REVIEW
	D. BIRKHOLZ JR.
	DATE
	5/90

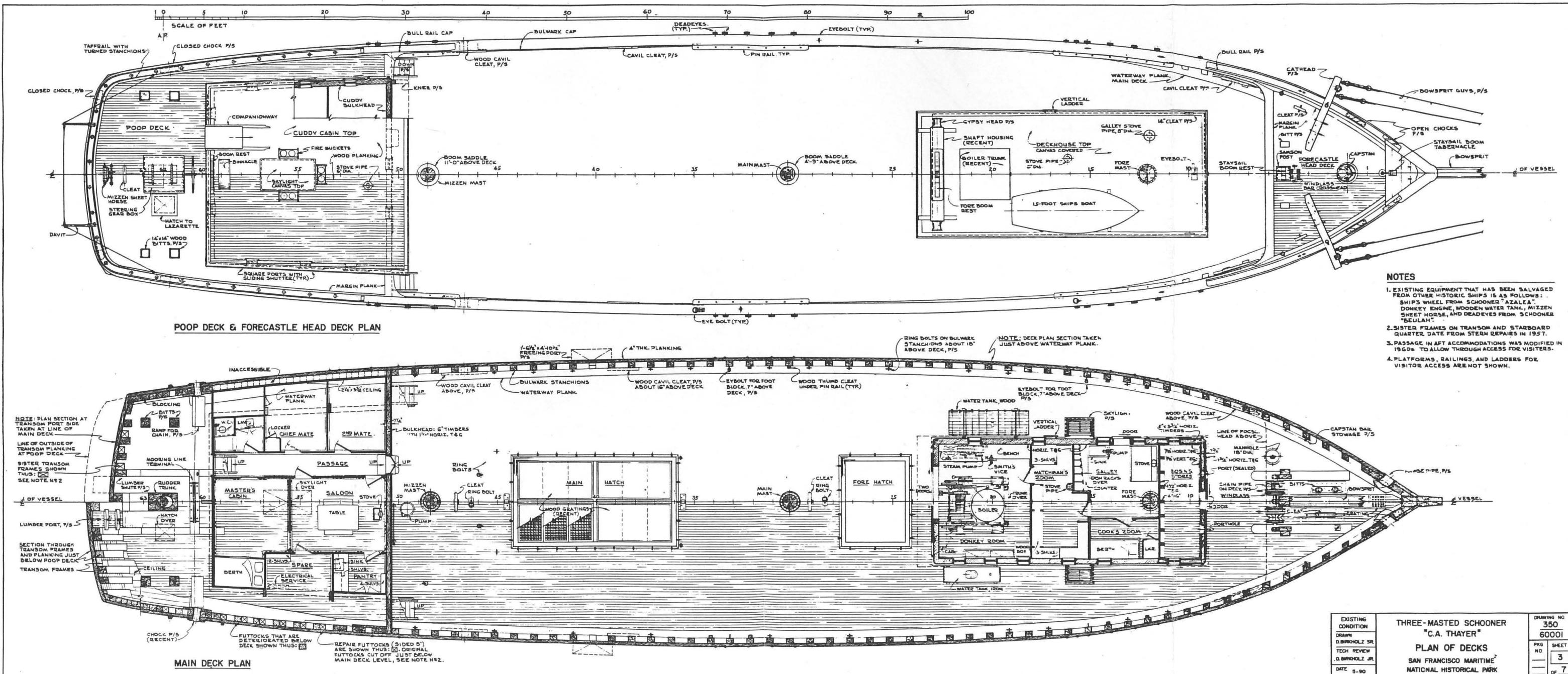
THREE-MASTED SCHOONER
"C.A. THAYER"
OUTBOARD PROFILE
SAN FRANCISCO MARITIME
NATIONAL HISTORICAL PARK

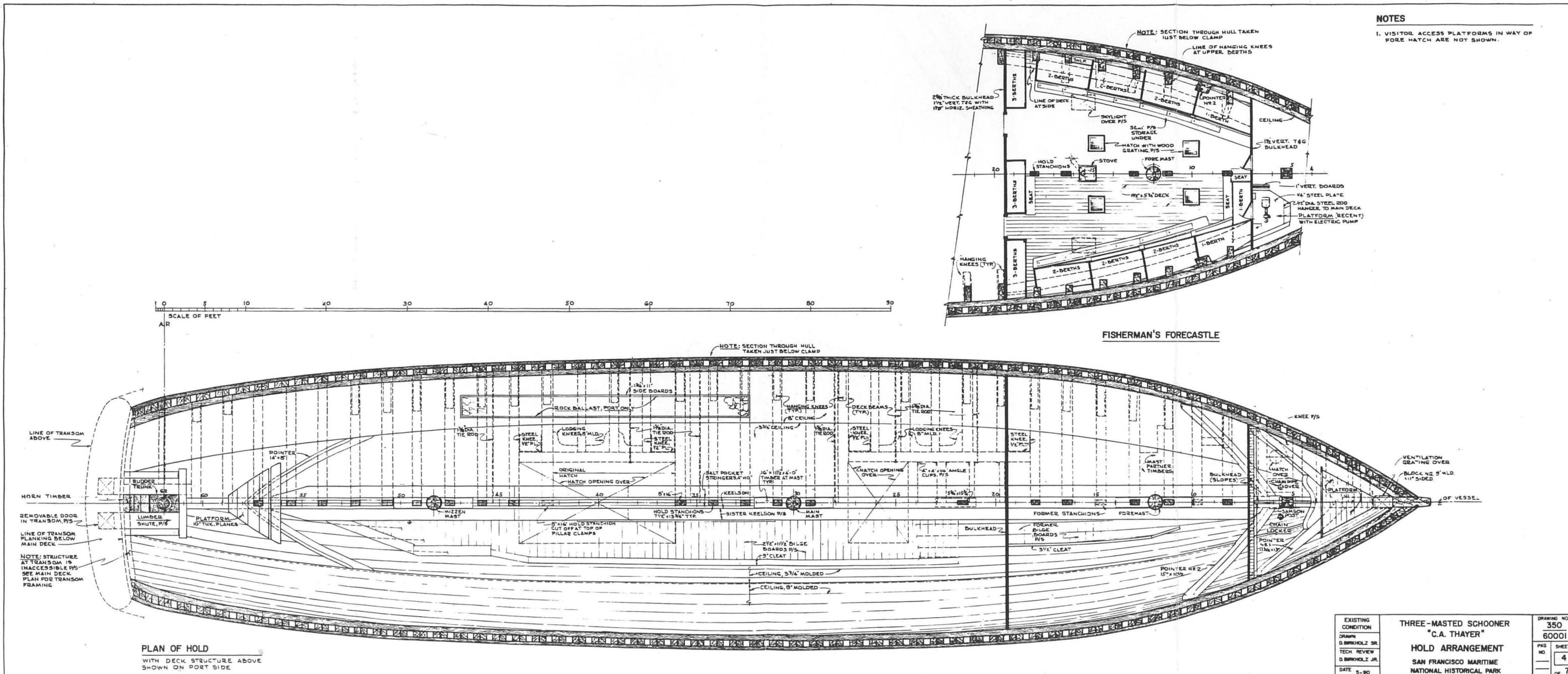
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NOTES

1. INTERNAL HULL STRUCTURE AT THE BOW AND STERN HAS NOT BEEN DOCUMENTED DUE TO LACK OF ACCESS. ARRANGEMENT AND DIMENSIONS GIVEN ARE APPROXIMATE ONLY.
2. VESSEL IS SHOWN WITHOUT EXISTING HOG. HOG HAS BEEN MEASURED AT 14" (DEC., 1968) WITH MAXIMUM HOG AT FRAME 34.

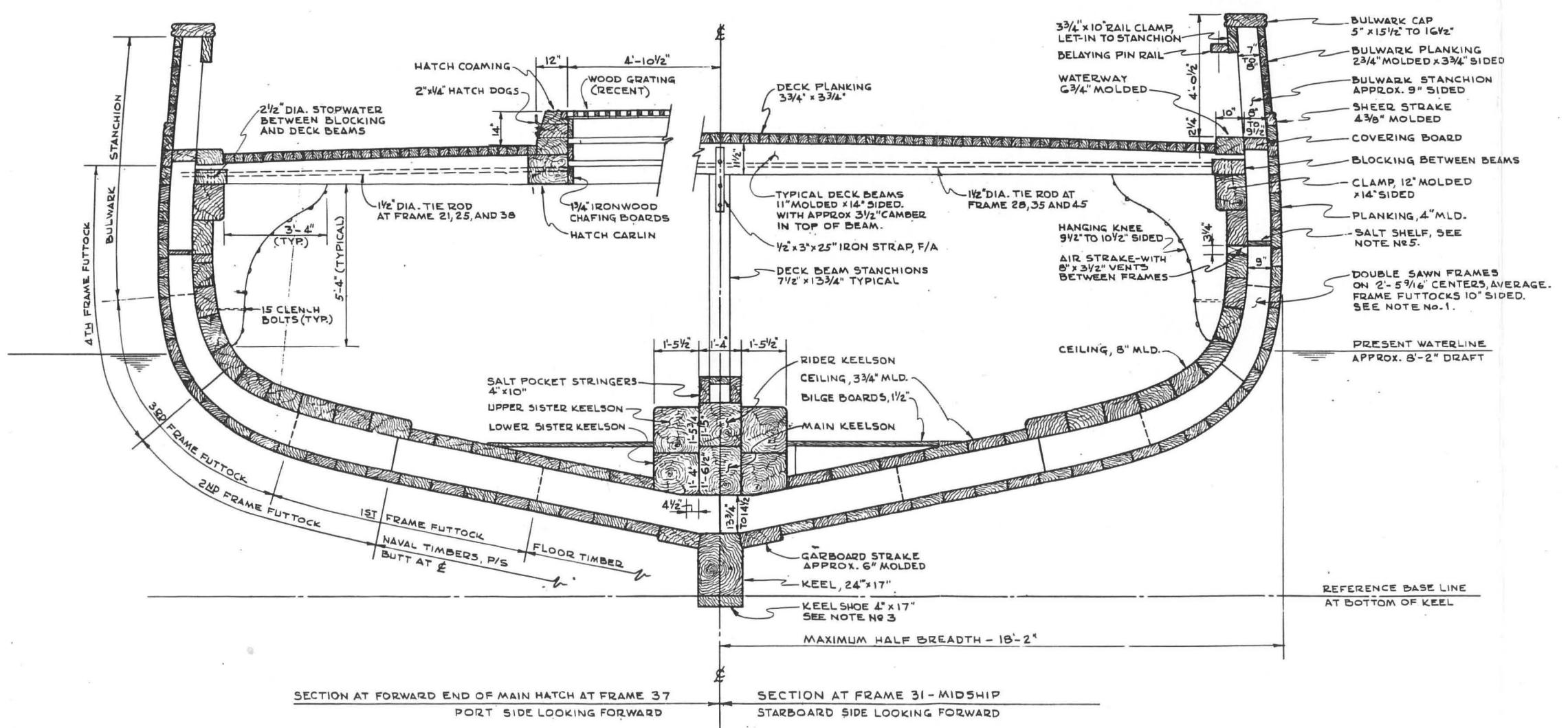






NOTES

1. ARRANGEMENT OF FUTTOCKS BELOW THE TURN-OF-BILGE IS APPROXIMATE, BASED ON DOCUMENTATION BY IVAN DUNCAN, FORMER SHIPWRIGHT FOREMAN FOR THE SAN FRANCISCO MARITIME STATE HISTORICAL PARK.
2. SIDED DIMENSIONS OF BOTTOM PLANKING ARE APPROXIMATE (EXCEPT FOR GARBOARD STRAKE) AND ARE BASED ON AN EARLIER MIDSHIP SECTION DRAWING BY I. DUNCAN.
3. KEEL SHOE WAS REMOVED IN 1989 AND REPLACED WITH COPPER SHEATHING.
4. SEAMS IN 8"-MOLDED CEILING ARE GENERALLY WEDGED.
5. FASTENING PATTERNS ARE NOT SHOWN.



MIDSHIP SECTION

A horizontal line representing a scale. It has several tick marks along its length. A point labeled 'O' is marked with a circle on the line, located between the first and second tick marks from the left.

SECTION AT FRAME 31 - MIDSHIP
STARBOARD SIDE LOOKING FORWARD

EXISTING CONDITION	THREE-MASTED SCHOONER "C.A. THAYER"
DRAWN	
D. BIRKHOLZ SR.	
TECH. REVIEW	MIDSHIP SECTION
D. BIRKHOLZ JR.	
DATE 5-90	SAN FRANCISCO MARITIME NATIONAL HISTORICAL PARK

DRAWING NO. 350
60001
PKG. NO. SHEET 5
DE 7

